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FONTEC – CORFO

CODIGO : **199 – 2024**

TITULO : **FABRICACIÓN DE RADIADORES CON NUEVA TECNOLOGÍA CUPROBRAZE**

EMPRESA GESTORA : **RADIADORES GALLARDO LAPAPORTE S.A.**

FECHA : **Octubre 2001**

629.23
R 129
2001

PRESENTACIÓN

En el último decenio, se constata que el país ha sabido enfrentar con éxito el desafío impuesto por la política de apertura en los mercados internacionales, alcanzando un crecimiento y desarrollo económico sustentable, con un sector empresarial dinámico, innovador y capaz de adaptarse rápidamente a las señales del mercado.

Sin embargo, nuestra estrategia de desarrollo, fundada en el mayor esfuerzo exportador y en un esquema que principalmente hace uso de las ventajas comparativas que dan los recursos naturales y la abundancia relativa de la mano de obra, tenderá a agotarse rápidamente como consecuencia del propio progreso nacional. Por consiguiente, resulta determinante afrontar una segunda fase exportadora que debe estar caracterizada por la incorporación de un mayor valor agregado de inteligencia, conocimientos y tecnologías a nuestros productos, a fin de hacerlos más competitivos.

Para abordar el proceso de modernización y reconversión de la estructura productiva del país, reviste vital importancia el papel que cumplen las innovaciones tecnológicas, toda vez que ellas confieren sustentación real a la competitividad de nuestra oferta exportable. Para ello, el Gobierno ofrece instrumentos financieros que promueven e incentivan la innovación y el desarrollo tecnológico de las empresas productoras de bienes y servicios.

El Fondo Nacional de Desarrollo Tecnológico y Productivo FONTEC, organismo creado por CORFO, cuenta con los recursos necesarios para financiar Proyectos de Innovación Tecnológica, formulados por las empresas del sector privado nacional para la introducción o adaptación y desarrollo de productos, procesos o de equipos.

Las Líneas de financiamiento de este Fondo incluyen, además, el apoyo a la ejecución de proyectos de Inversión en Infraestructura Tecnológica y de Centros de Transferencia Tecnológica a objeto que las empresas dispongan de sus propias instalaciones de control de calidad y de investigación y desarrollo de nuevos productos o procesos.

De este modo se tiende a la incorporación del concepto "Empresa - País", en la comunidad nacional, donde no es sólo una empresa aislada la que compite con productos de calidad, sino que es la "Marca - País" la que se hace presente en los mercados internacionales.

El Proyecto que se presenta, constituye un valioso aporte al cumplimiento de los objetivos y metas anteriormente comentados.

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A) Resumen Ejecutivo

- Antecedentes de la Empresa
- Síntesis del proyecto de Innovación
- Principales Resultados del Proyecto y Conclusiones

a) Resumen Ejecutivo

Antecedentes de la Empresa

Radiadores Gallardo Laporte S.A., Rut. 96.803.940 – 7 fue constituida en Santiago de Chile el 17 de Diciembre de 1996 ante el notario publico Doña Mercedes Moreno Guemes, titular de la Primera Notaría de Santiago, anotada en el repertorio Nª 174.641 e inscrita a fs. 33100 Nº 25.869 del año 1996.

La empresa tiene como giro el Diseño, Fabricación y Servicio (Reparación y Mantención) de Radiadores e Intercambiadores de Calor.

Radiadores

- Panales Automotrices e Industriales
- Radiadores de Automotrices e Industriales
- Radiadores de Tubos Intercambiables

Intercambiadores de Calor

- Haz Tubular/Carcaza
- Enfriadores de Aceite/Aire
- Sistema de Tubos Aleteados

BIBLIOTECA CORFO

Síntesis del proyecto de Innovación

Cuprobraze, es una tecnología desarrollada por Outokumpu e ICA (Asoc. Internacional de Cobre) , para competir con los Radiadores Aluminio / Plástico que han reemplazando el uso de Cu en el mercado OEM (Original Equipment Manufacture) y gran parte del Mercado de Reposición (Aftermarket).

Outokumpu ofrece a Radiadores Gallardo Laporte S.A. la Transferencia de esta nueva Tecnología.

Esta tecnología Mejora las prestaciones de servicio y AMBIENTALES en relación al los Radiadores de Cu tradicional y los de Al. Los Radiadores de Cobre son más resistentes a la corrosión, impacto y vibraciones que los de Al.

Esta tecnología disminuye costos de Producción.

En Chile se importan USD 3.000.000.- al año en Radiadores, principalmente de Aluminio / Plástico, lo que implica un gran potencial de sustitución de importaciones y luego de exportación.

Tecnología Cuprobraze se desarrollo pensando en el Medio Ambiente.

Es una aleación autofundente, por lo que no utiliza fundente, plomo, ni otro mineral contaminante. La Aleación de Cobre no posee Cadmio.

El Ciclo completo de los Radiadores Cuprobraze es significativamente más ecológico que el de Aluminio, desde la extracción de la materia prima hasta el reciclado de los radiadores fuera de uso.

El objetivo de esta tecnología es recuperar y sustituir el uso del aluminio en la fabricación de Radiadores.

Se busca el estudio e implementación de un proceso piloto que permita la adaptación de la tecnología para fabricar Radiadores CUPROBRAZE, a una escala adaptada a la realidad nacional.

Evaluar e investigar el uso de esta tecnología en la fabricación de intercambiadores de calor industriales e Intercoolers.

Principales Resultados del Proyecto y Conclusiones

Se produce la Transferencia Tecnológica de Outokumpu a Radiadores Gallardo Laporte S.A.

La tecnología Cuprobraze presenta un gran potencial y cuenta con el respaldo de Outokumpu y otros productores mundiales de Cobre. Ademas de ICA. El objetivo final es recuperar terreno perdido con el Aluminio.

La tecnología Cuprobraze esta en su etapa de introducción y varios fabricantes en el mundo están en su etapa experimental y estudiando la implementación en otras aplicaciones a los radiadores de agua como Intercooler y enfriadores de Aceite.

Se fabrica maquinaria para proceso y construcción de prototipo..

Se fabrica prototipo de Panal Automotriz con tecnología Cuprobraze, con resultado positivo.

Se investiga en productos como enfriadores de aceite e intercoolers.

Radiadores Gallardo Laporte S.A. fabrica un prototipo de Enfriador de Aceite / Aire para ser desarrollado con tecnología Cuprobraze.

Se fabricará un prototipo que se ha estado desarrollando para fabricar Charge Air Cooler en Cobre o intercooler, el que será evaluado por Outokumpu.

Se establece relación de trabajo de largo plazo con Outokumpu para el desarrollo de esta tecnología y se tiene acceso a uso del centro Técnico de Outokumpu. Esto implica trasferencia tecnológica permanente, asistencia técnica, acceso a sus laboratorios, uso de maquinaria para construcción de prototipos y uso de tunel de viento para evaluación de productos.

B) Exposición del Problema

- Antecedentes Técnicos del Proyecto
- Objetivos Técnicos y Resultados Perseguidos
- Tipo de Innovación Desarrollada

Antecedentes Técnicos del Proyecto

- Tecnología desarrollada por Outokumpu e ICA (Asoc. Internacional de Cobre) , para competir con los Radiadores Aluminio / Plástico que están reemplazando el uso de Cu en esta Aplicación.
- Outokumpu ofrece a Radiadores Gallardo Laporte S.A. La Transferecia de esta nueva Tecnología Llamada Cuprobraze.
- Tecnología Mejora Prestaciones de Servicio y AMBIENTALES en relación al los Radiadores de Cu tradicional y los de Al.

Antecedentes Técnicos del Proyecto

- El Cobre es la principal actividad económica de Chile.
- Esta tecnología disminuye costos de Producción.
- Los Radiadores de Cobre son más resistentes a la corrosión, impacto y vibraciones que los de Al.
- En Chile se importan USD 3.000.000.- al año en Radiadores, principalmente de Aluminio / Plástico, lo que implica un gran potencial de sustitución de importaciones y luego de exportación.

Antecedentes Técnicos del Proyecto

- Tecnología Cuprobraze se desarrollo pensando en el Medio Ambiente.
- Es una aleación autofundente, por lo que no utiliza fundente, plomo, ni otro mineral contaminante. La Aleación de Cobre no posee Cadmio.
- El Ciclo completo de los Radiadores Cuprobraze es significativamente más ecológico que el de Aluminio, desde la extracción de la materia prima hasta el reciclado de los radiadores fuera de uso.

Objetivos del proyecto

- Estudio e implementación de un proceso piloto que permita la adaptación de la tecnología para fabricar Radiadores CUPROBRAZE, a una escala adaptada a la realidad nacional.

BIBLIOTECA CORFO

Objetivos del proyecto

- Evaluar e investigar la aplicación de la tecnología CUPROBRAZE, en la fabricación de Intercambiadores de Calor e Intercoolers.

Tipo de Innovación Desarrollada

- Transferencia de Tecnología Cuprobraze y adaptación de ésta a escala de producción y realidad Chilena.
- Nuevo Proceso para la Fabricación de Radiadores Automotrices.
- Desarrollo de Prototipos para la Fabricación de Enfriadores de Aceite Industriales en Cobre y con Tecnología Cuprobraze.

C) Metodología y Plan de Trabajo

- Recopilación de Antecedentes y Literatura entregada por Outokumpu.
- Visita a Outokumpu Suecia, Ingeniero Rafael Gallardo, para transferencia tecnológica.
- Fabricación de Máquinas y procesos prototipos.

C) Metodología y Plan de Trabajo

- Implementación de Procesos Piloto, Pruebas y Ensayo.
- Visita a Outokumpu Suecia, Rodrigo Gallardo, Jefe del Proyecto y Gerente General de Radiadores Gallardo Laporte S.A.

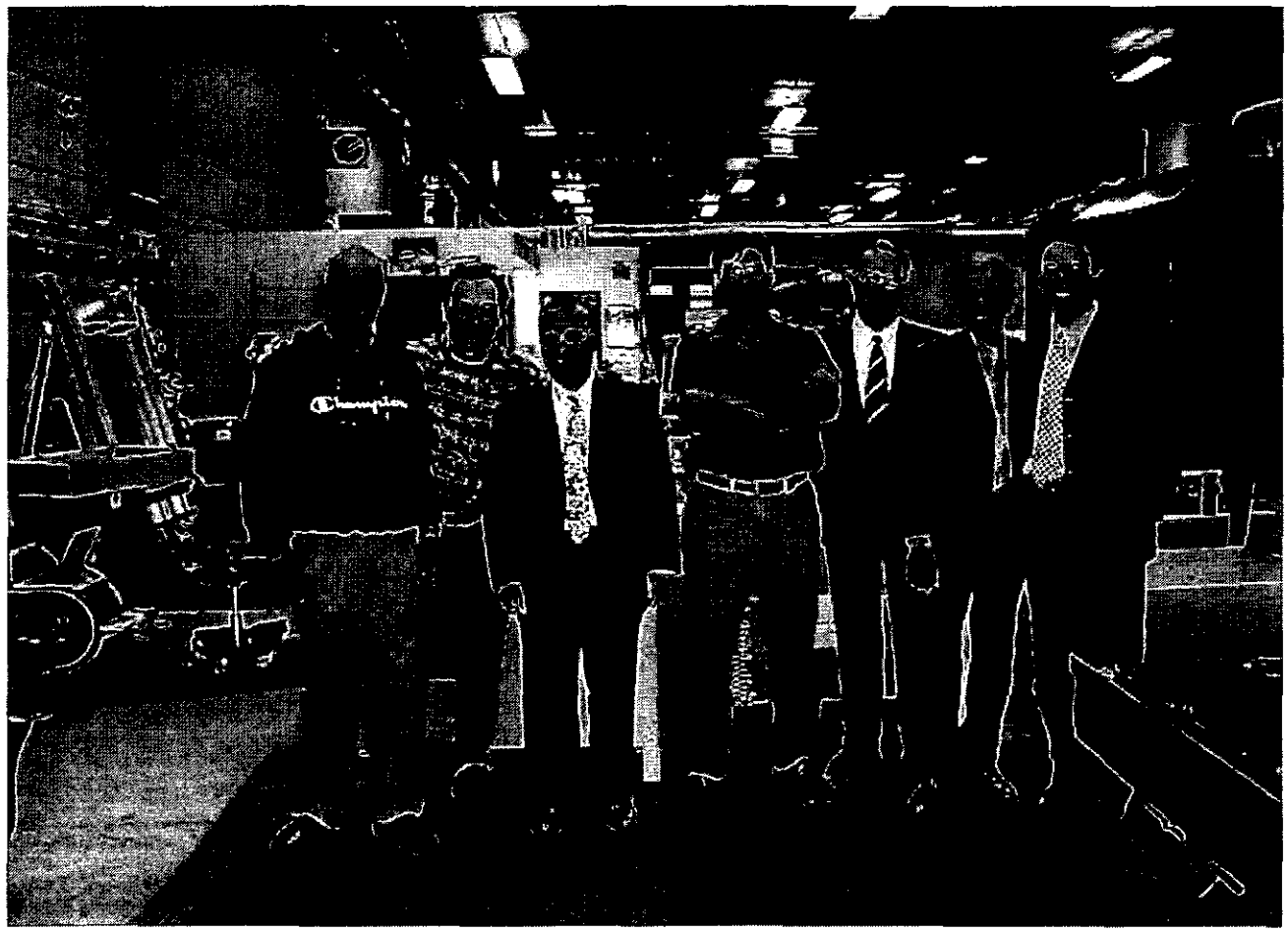
C) Metodología y Plan de Trabajo

- Fabricación Prototipo Panal Automotriz.
- Fabricación Prototipo Enfriador de Aceite, Pruebas a 100 psi sostenidos de Presión.
- Pruebas y Evaluación de Prototipos.

D) Resultados Obtenidos

- Transferencia Tecnológica
- Visita Ingeniero Rafael Gallardo Laporte a Centro Técnico y Planta Piloto Cuprobraze en Outokumpu, Suecia.
- Septiembre, Año 2000.

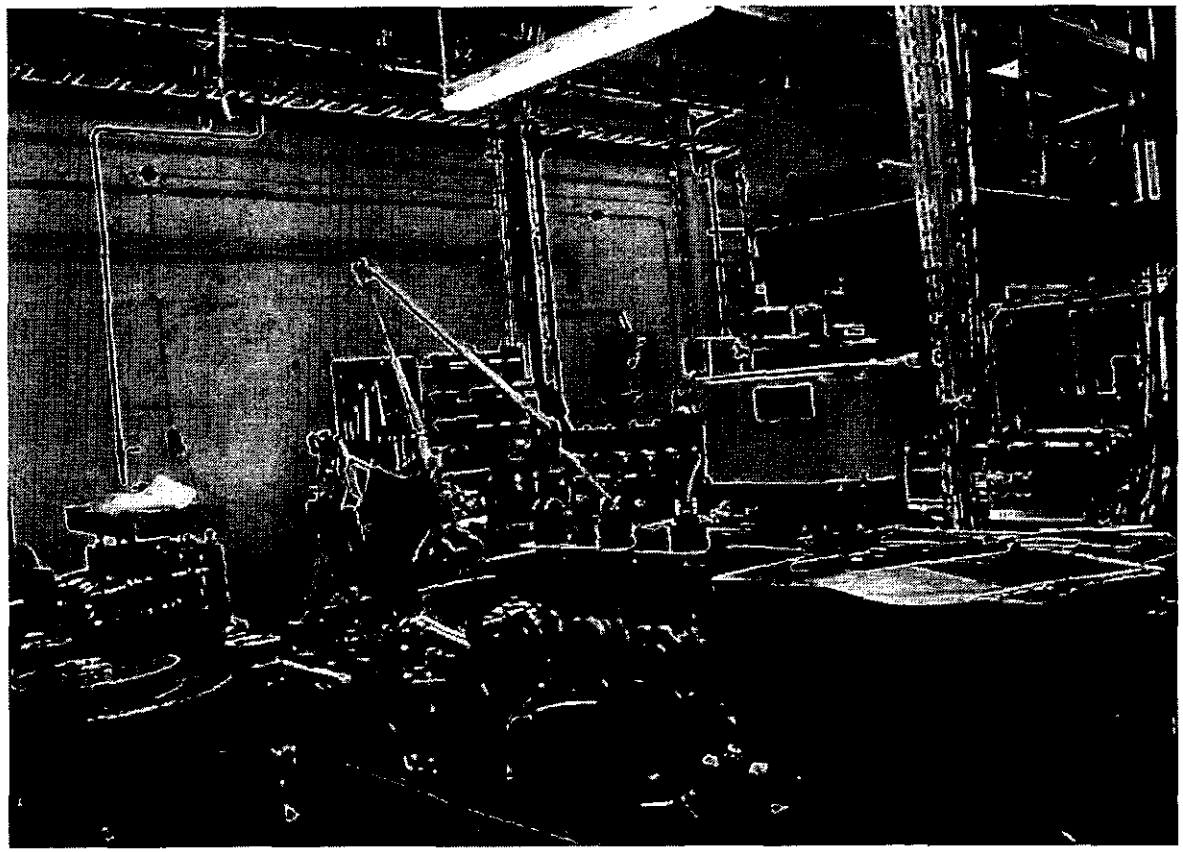
Outokumpu - Rgl S.A.



Equipo Cuprobraze de Outokumpu - Rafael Gallardo Laporte

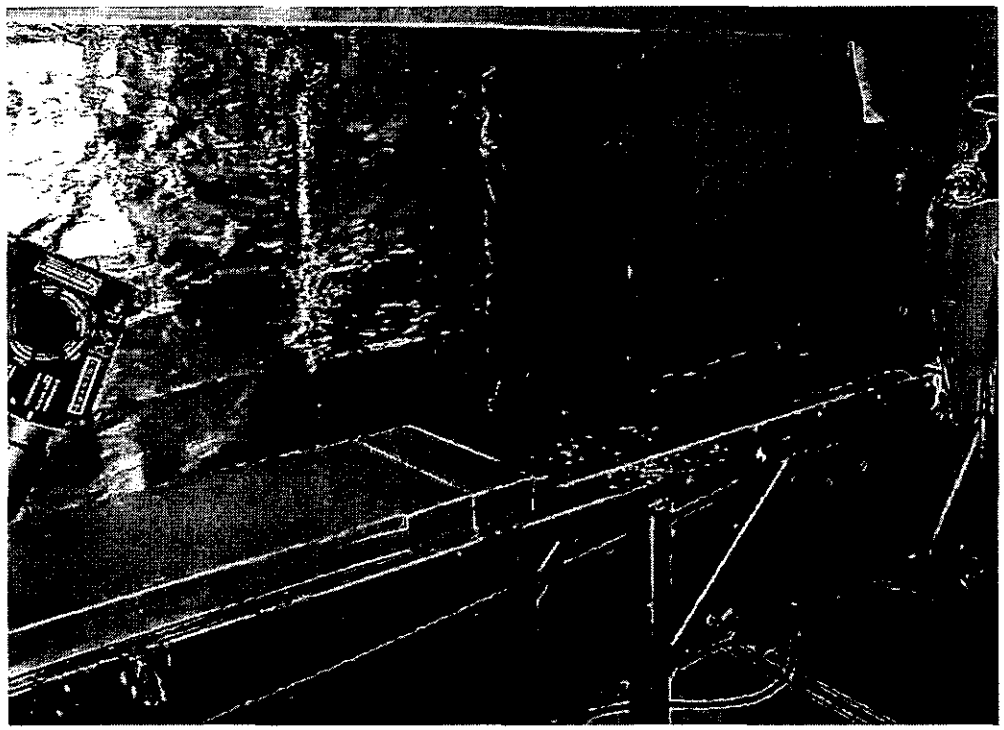
Máquina Tubera

Máquina que fabrica los tubos de Radiador.
El Radiador Cuprobraze funciona con tubos sin costura.
Se están haciendo pruebas con tubos emballetados para fábricas de menor escala de producción



Outokumpu - Suecia, Lab. Proyecto Cuprobraze

Secado de Tubos con Pasta



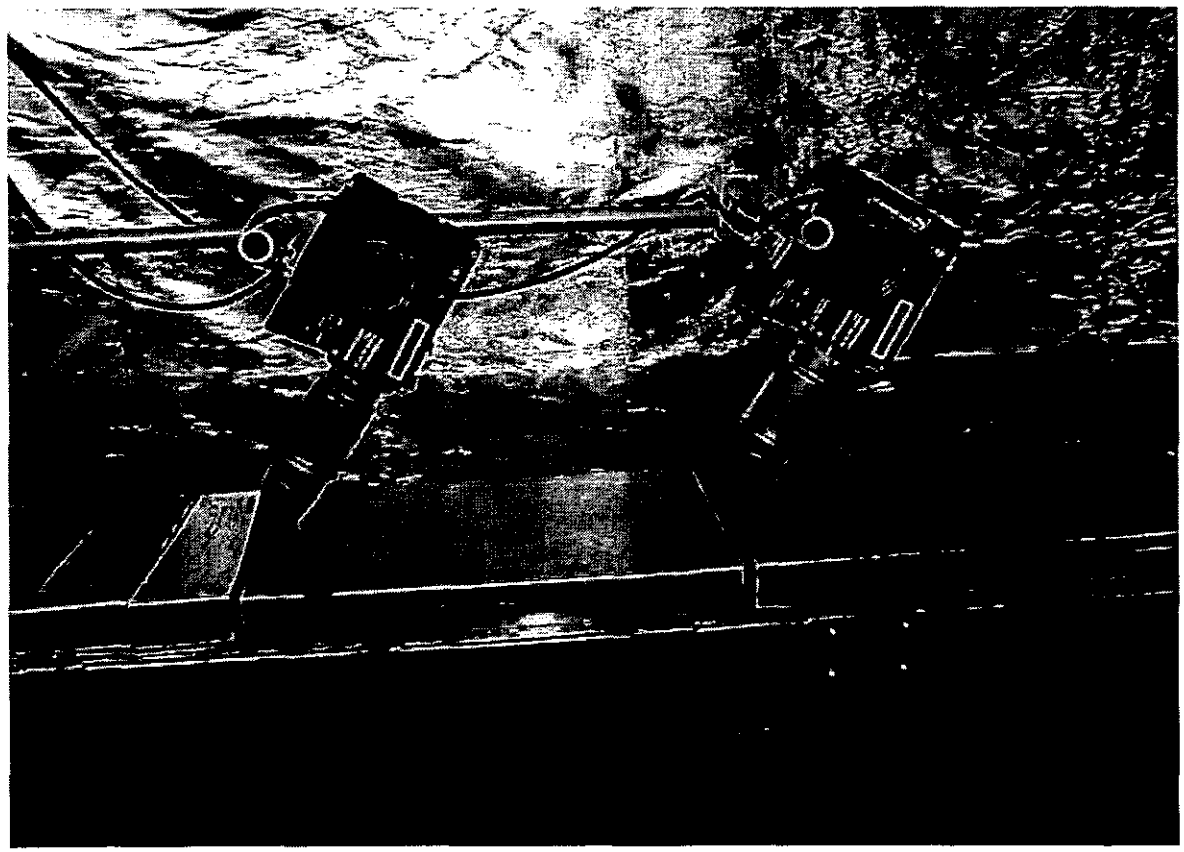
Outokumpu - Suecia
Laboratorio Proyecto
Cuprobraze

Se empasta tubo a tubo en forma manual y luego se ponen los tubos en esta bandeja transportadora para su secado.

Secado de Tubos con Pasta

Proceso Experimental de Secado de Tubos con Pasta de Brazado.

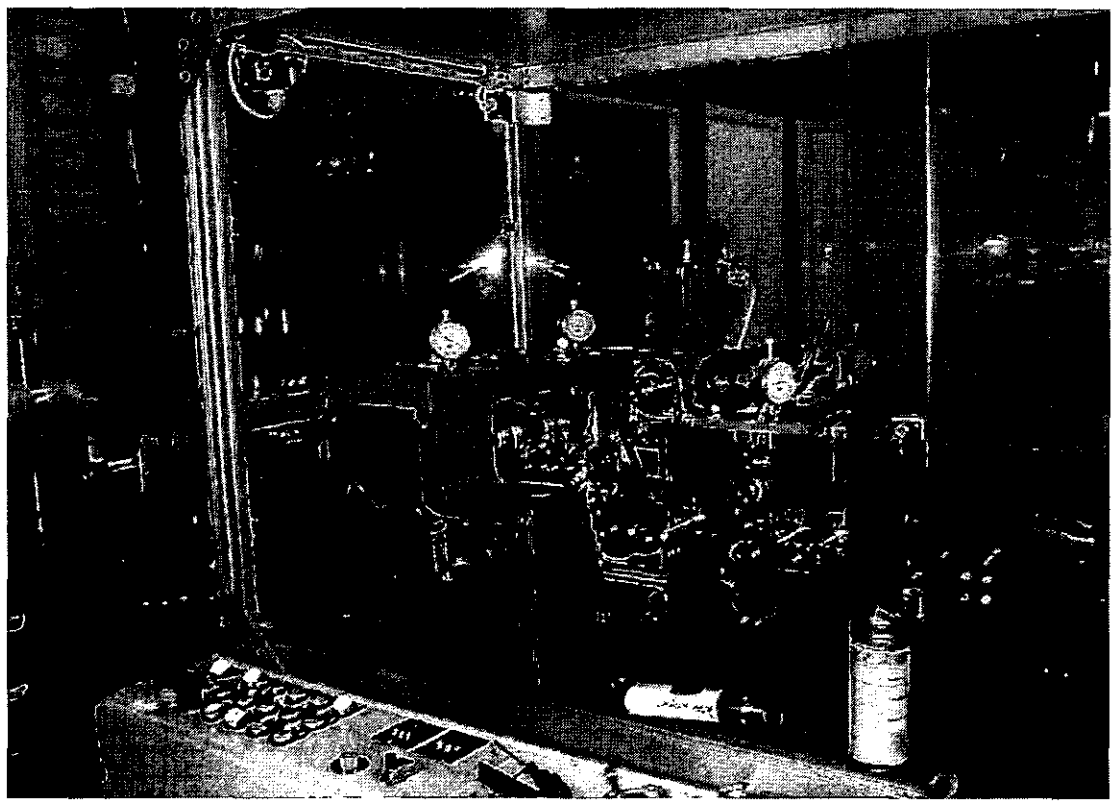
Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze



Máquina de Rodillo

Máquina de Rodillo para la fabricación de aletas o rizos de Radiadores.

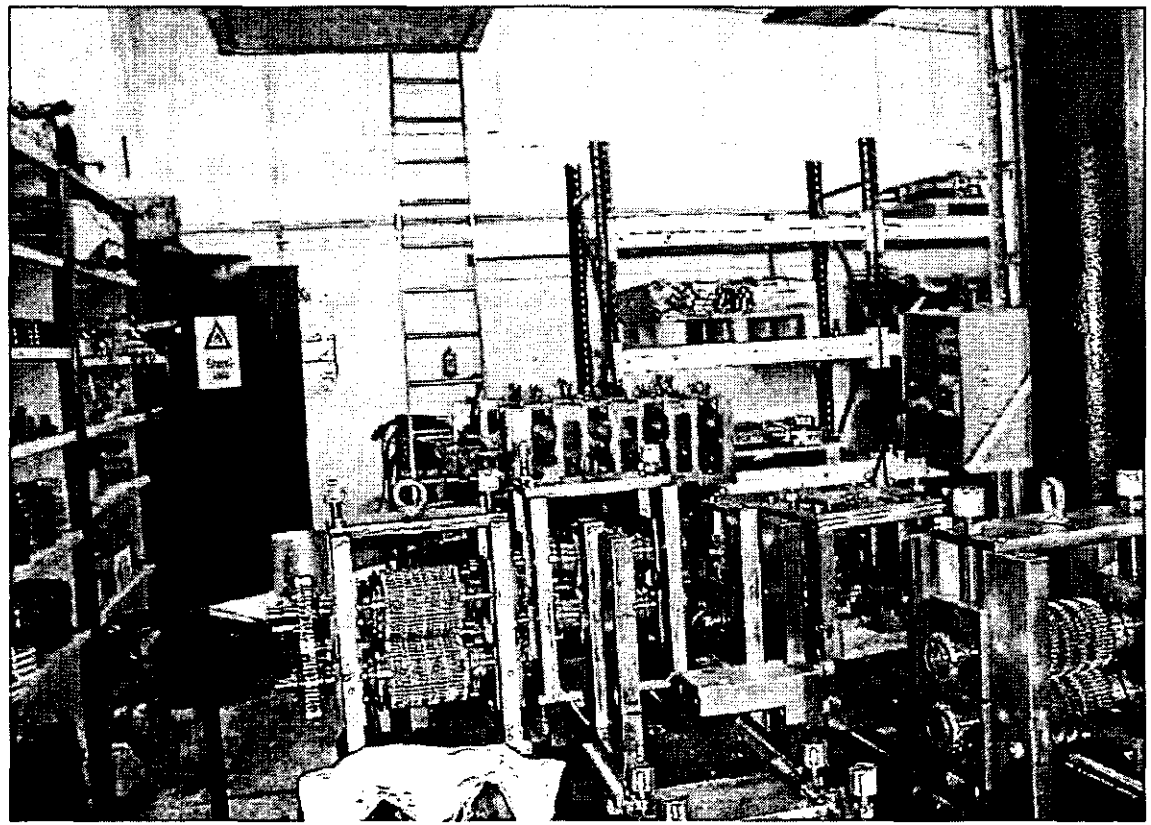
Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze



Rodillos para Máq. Aletas

Múltiples set de Rodillos para fabricar distintos tipos de Radiadores.

Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

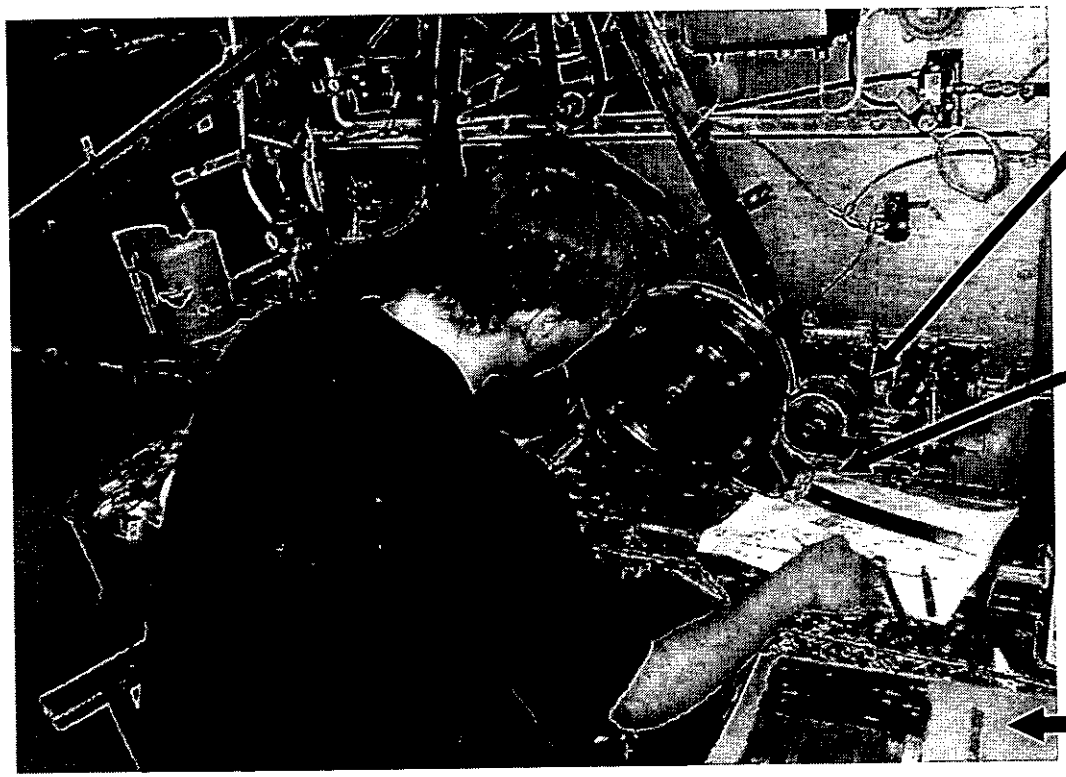


Aplicación de Pasta a Rizo

Outokumpu - Suecia
Laboratorio Proyecto
Cuprobraze

Experimentando formas de aplicar pasta de brazado a Rizo.
Se aprecia en la foto, forma de aplicar manual y distinta a la del Manual Técnico Cuprobraze, Feb. 2000.

Aplicación Pasta a Rizos



Rodillo con Pasta

Sacar exceso de Pasta

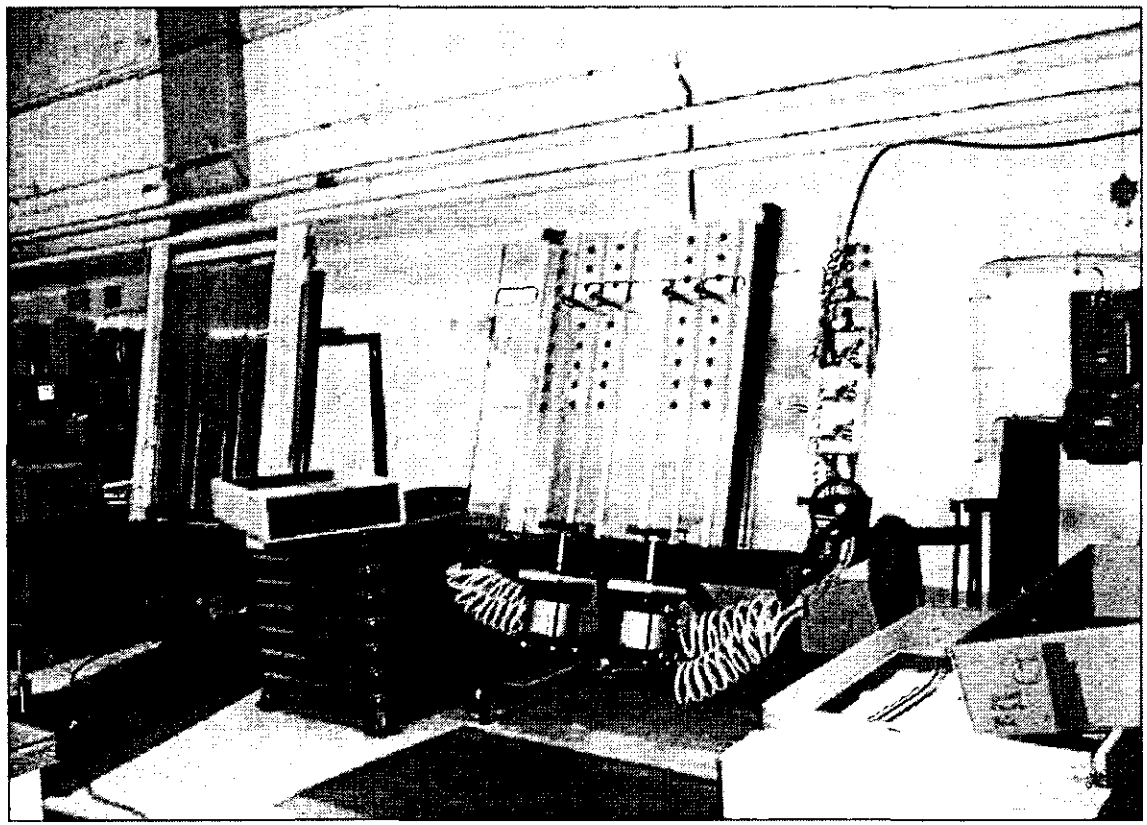
Rizos después de poner pasta

Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

Pruebas de Aplicación de Pasta de Brazado a Rizo

Mesa de Armado Panal

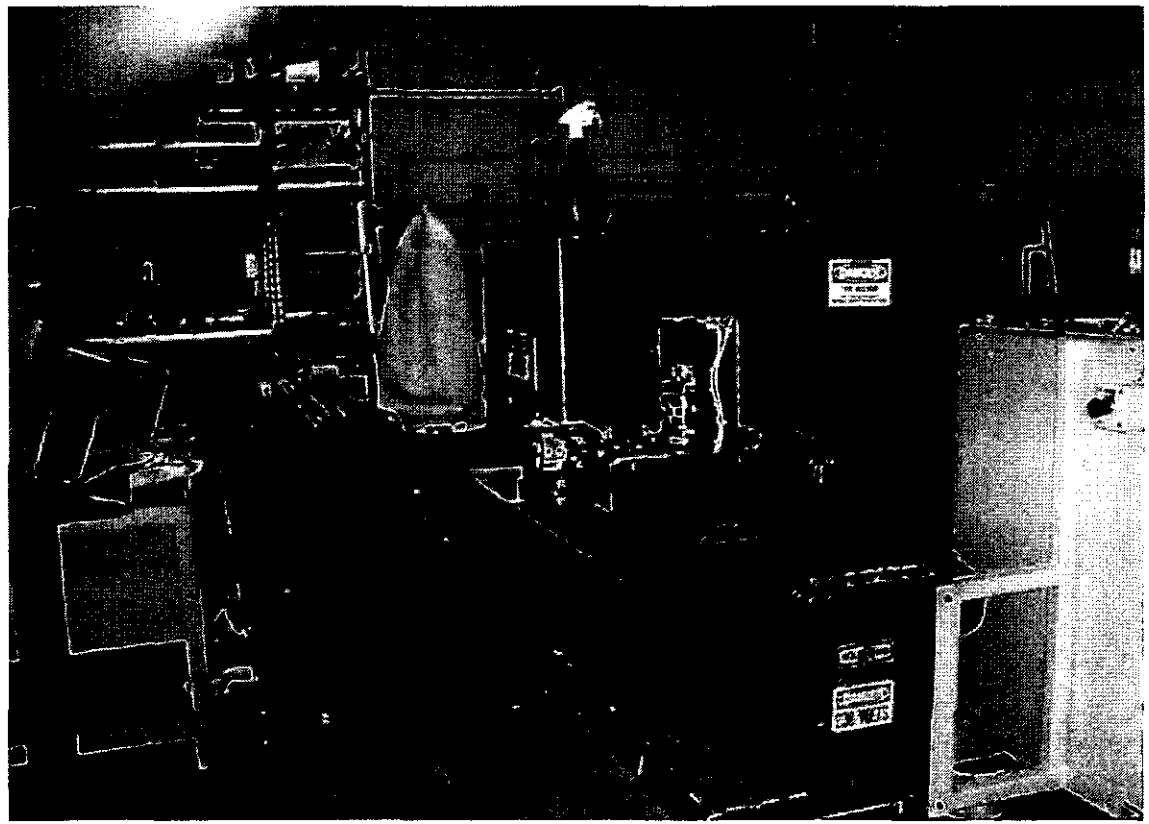
Mesa de Armado Panal, antes de tratamiento térmico (Horno)



Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

Fabricación de Colectores

Punzonadora de Control numérico para fabricar colectores.

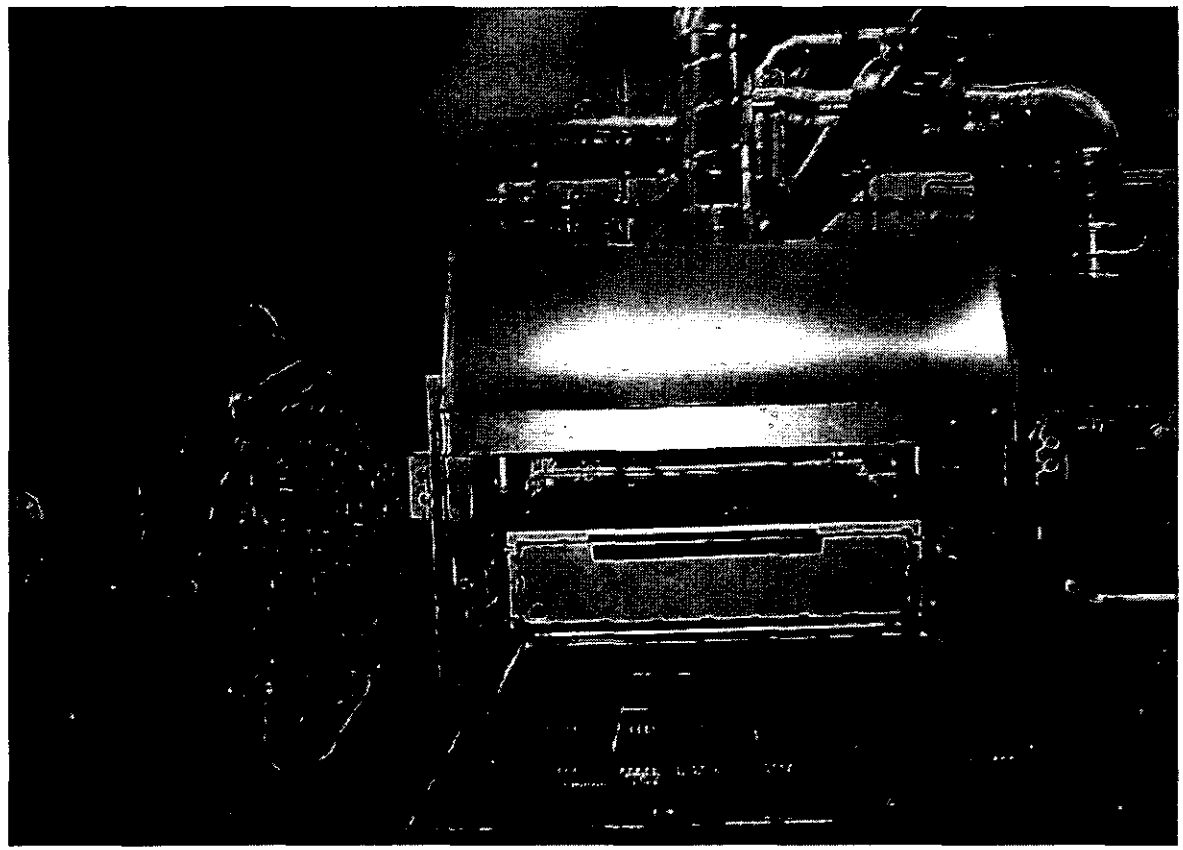


Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

Entrada del Horno

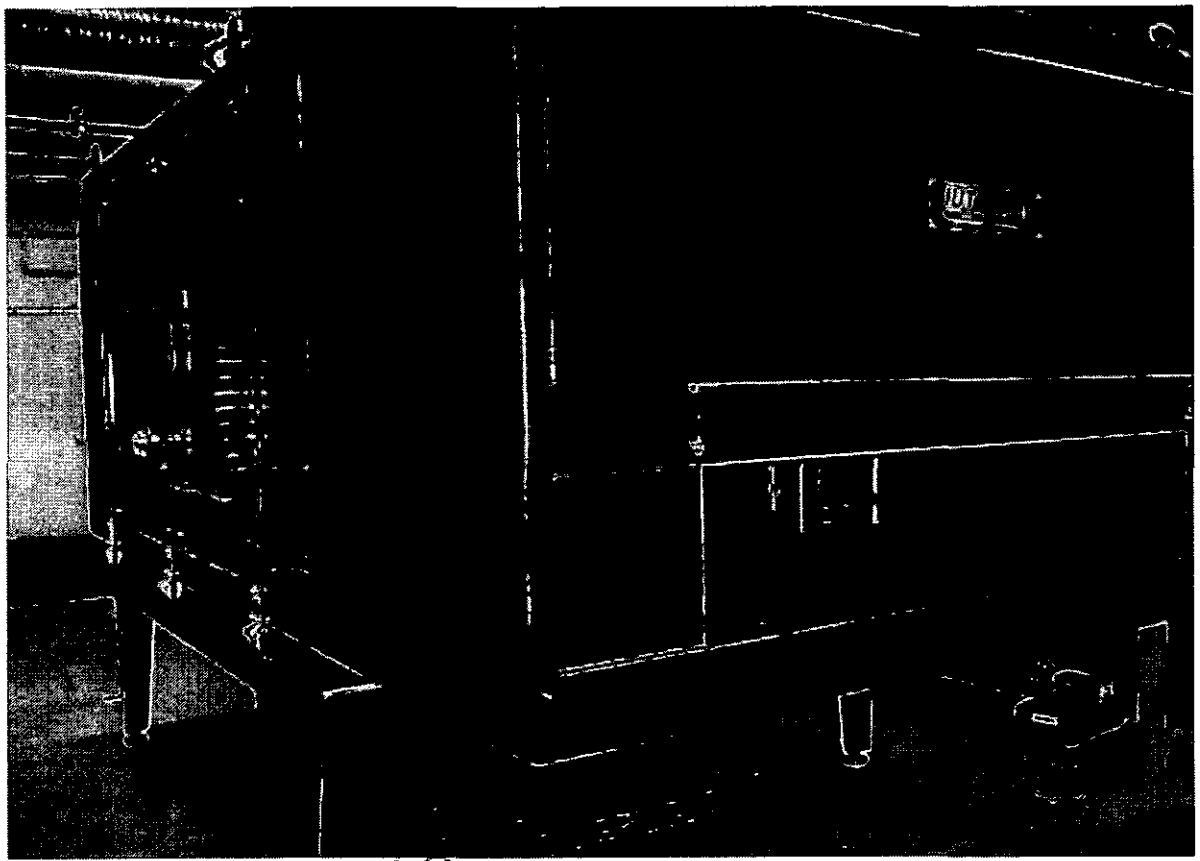
Se abre el carro para insertar Panal de Radiador Cuprobraze en el Horno

Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze



Precalentador Panal

Precalentador Panal antes de entrar al horno. Se estaba probando en varias etapas para tomar los 600° C.

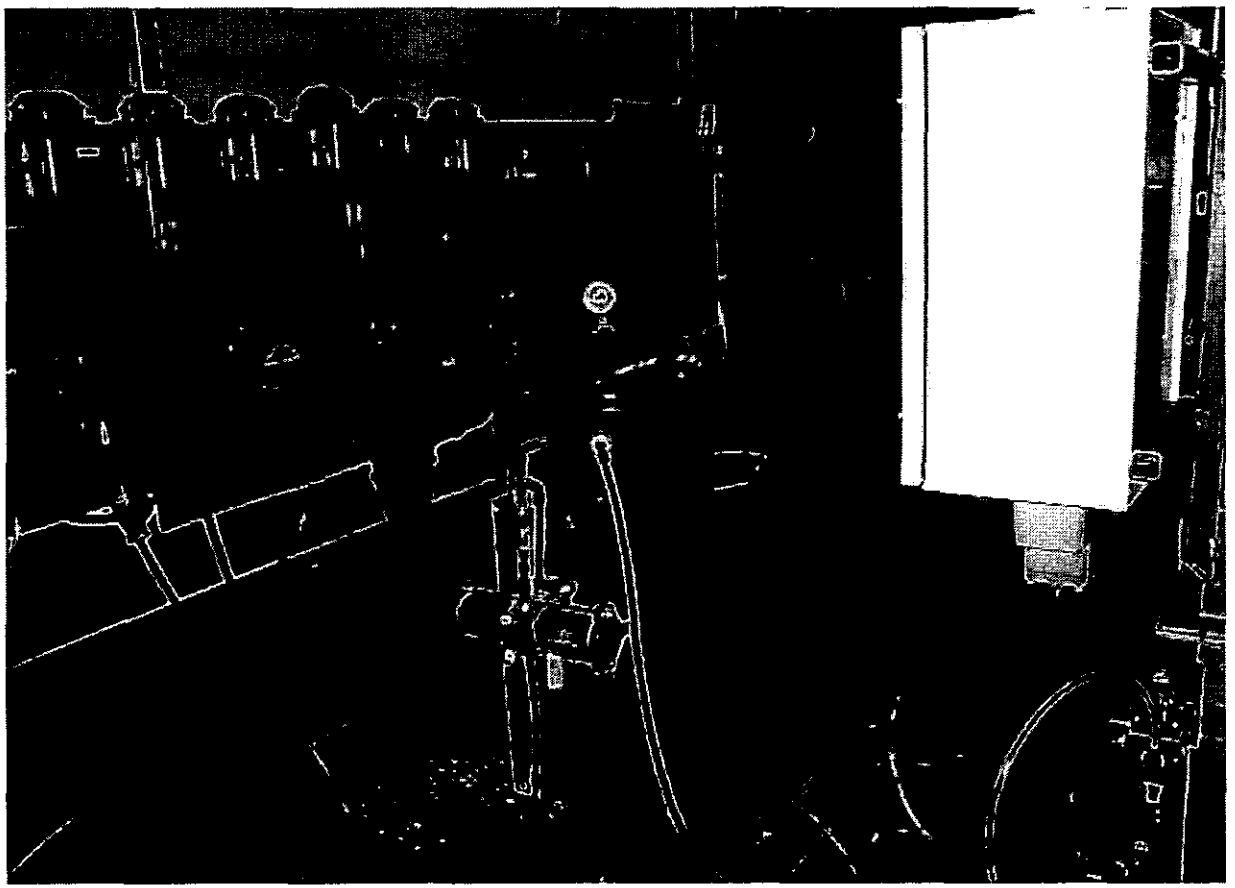


Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

CA CORFO

Estanque de Nitrógeno

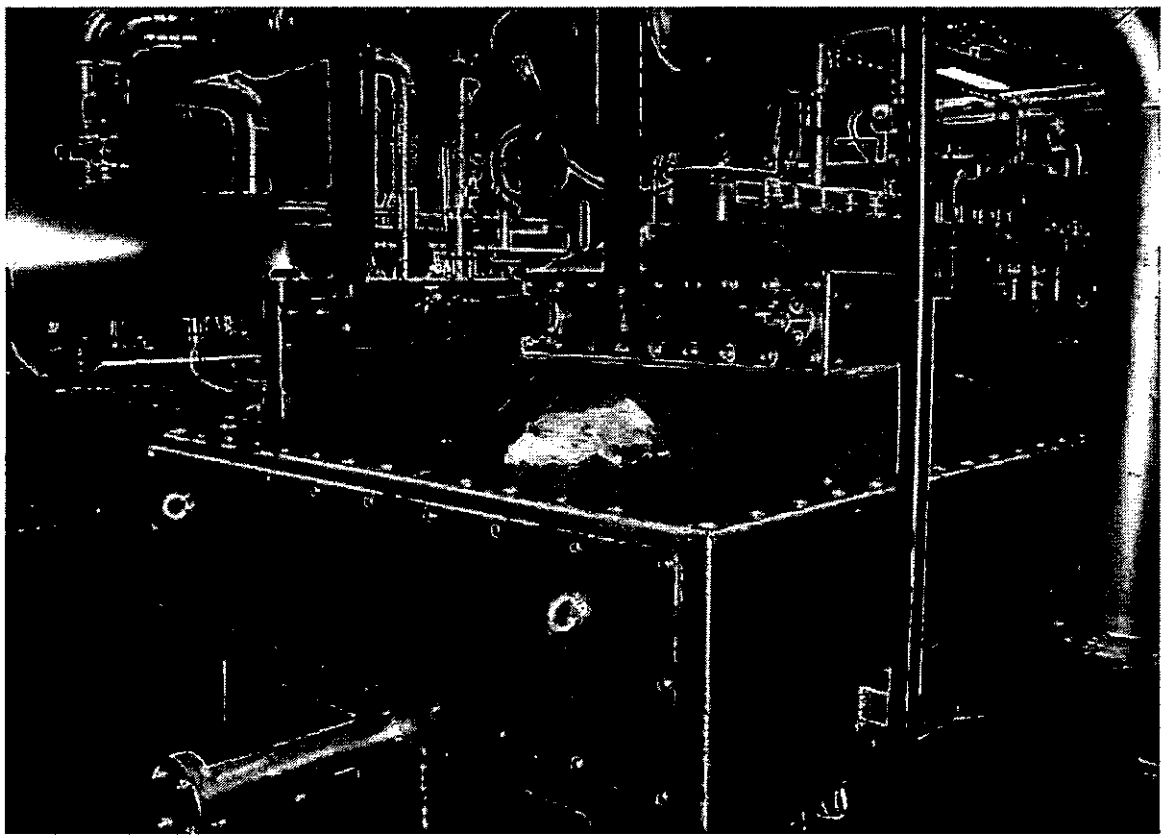
Estanque con Nitrógeno para inyectar al Horno de atmósfera controlada.



Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

Etapa Inyección Nitrógeno

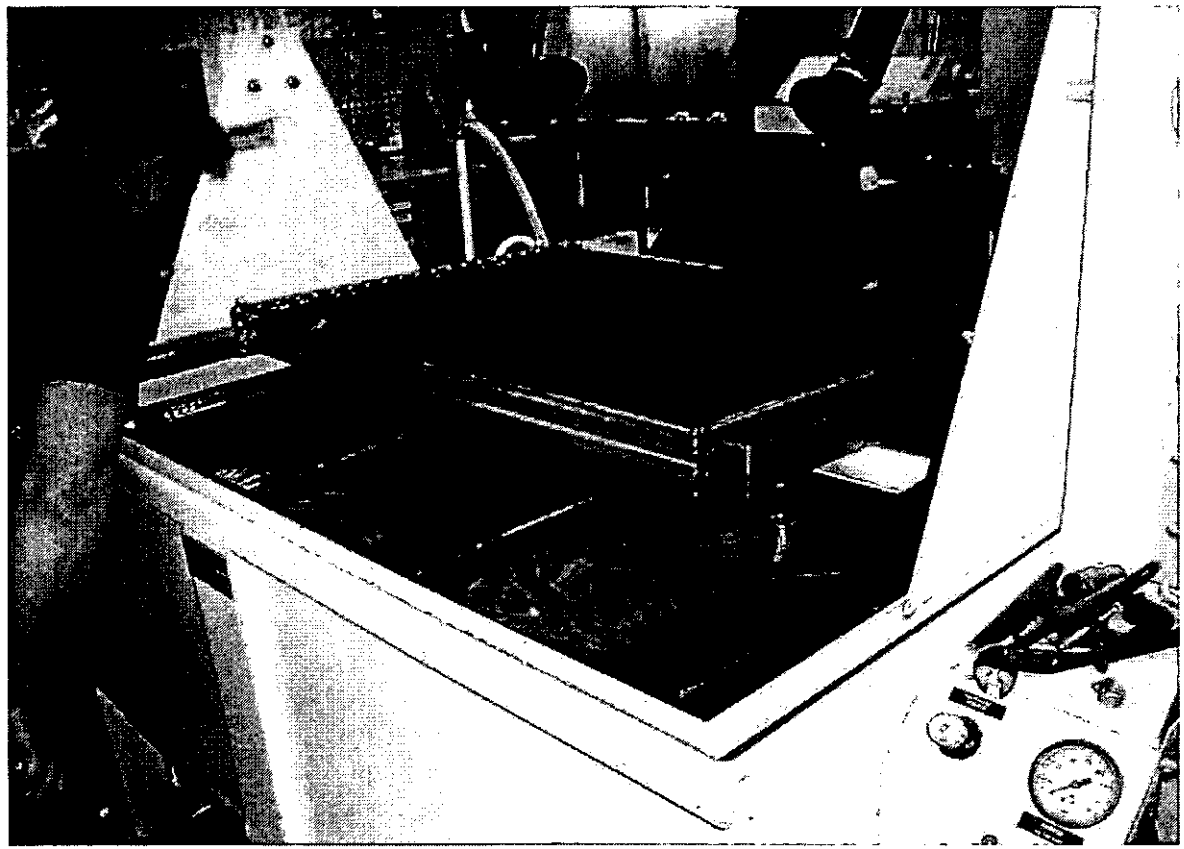
Etapa en que se inyecta nitrógeno al horno.



Outokumpu - Suecia
Laboratorio Proyecto Cuprobraze

Probando Radiador Industrial

Se están probando Radiadores Cuprobraze para Camiones con estanques apernados. Todavía hay problemas de filtración en la unión colector - tubos



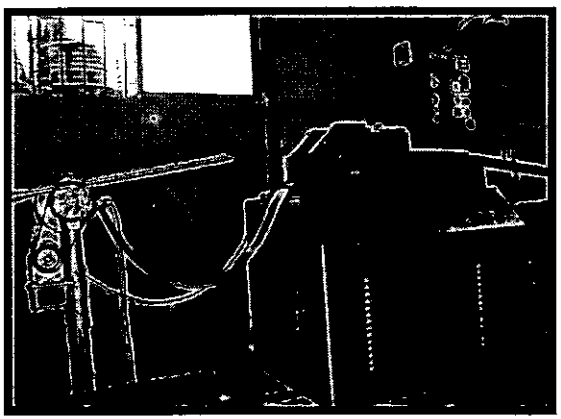
Outokumpu - Suecia, Laboratorio Proyecto Cuprobraze

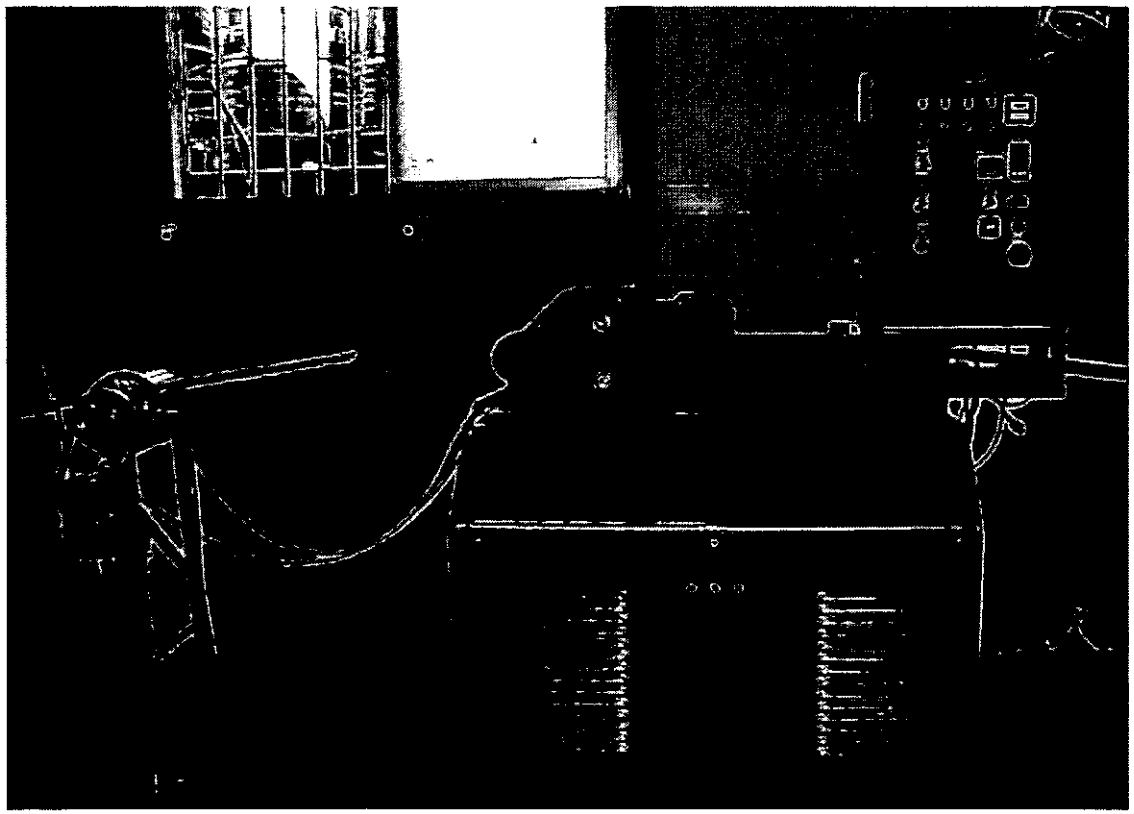
Radiadores Gallardo Laporte S.A.

- Máquina Estampadora de Aletas para Radiador Industrial
- Matriz para Estampar Colectores Industriales
- Tubera para Tubos emballetado.

Máquina Aletadora

Máquina Estampadora de Aletas para Radiador Industrial (100 %)





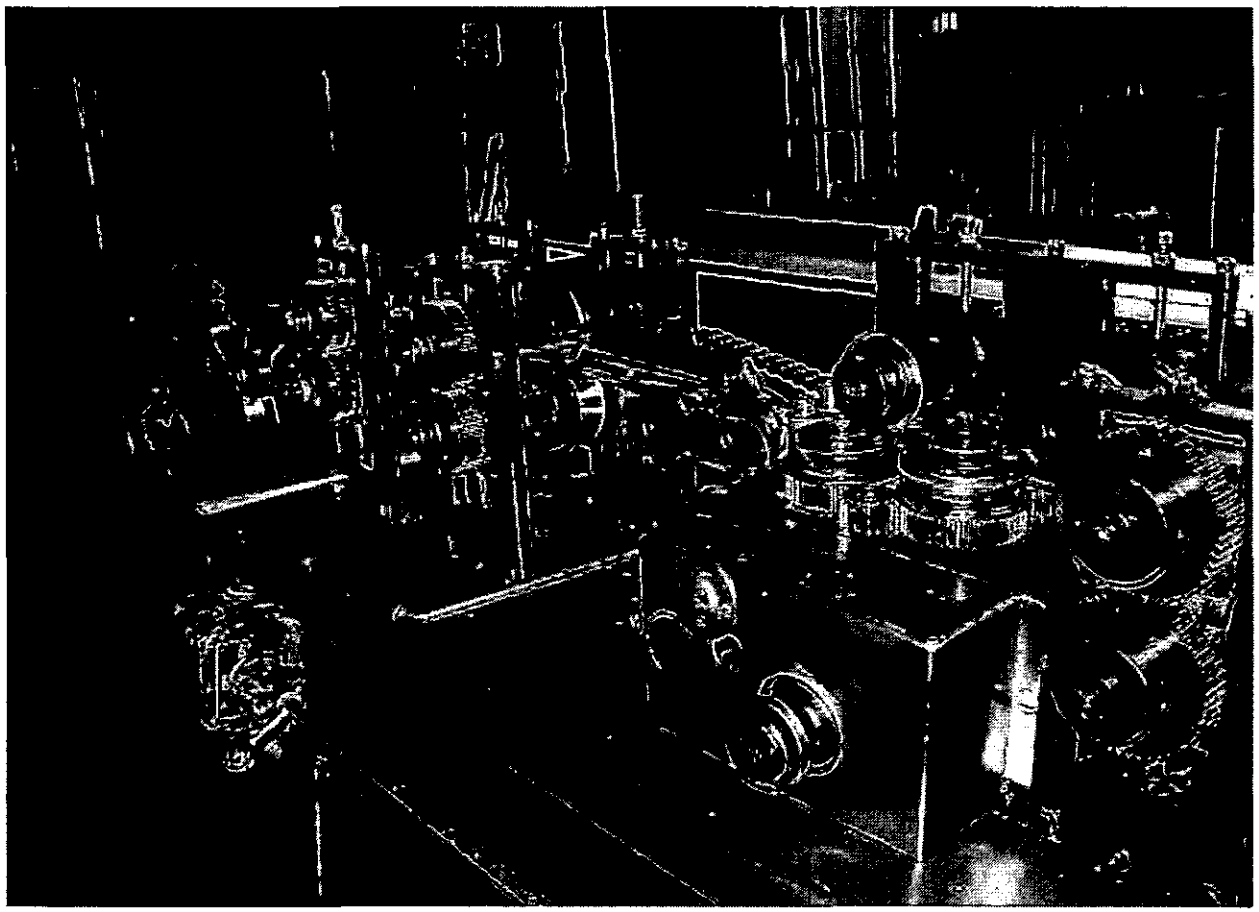
Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Matriz Colectores Industriales

Matriz para estampar colectores industriales.
80 % estado de avance.
En planta piloto Outokumpu utilizaban una punzonadora automática y programable

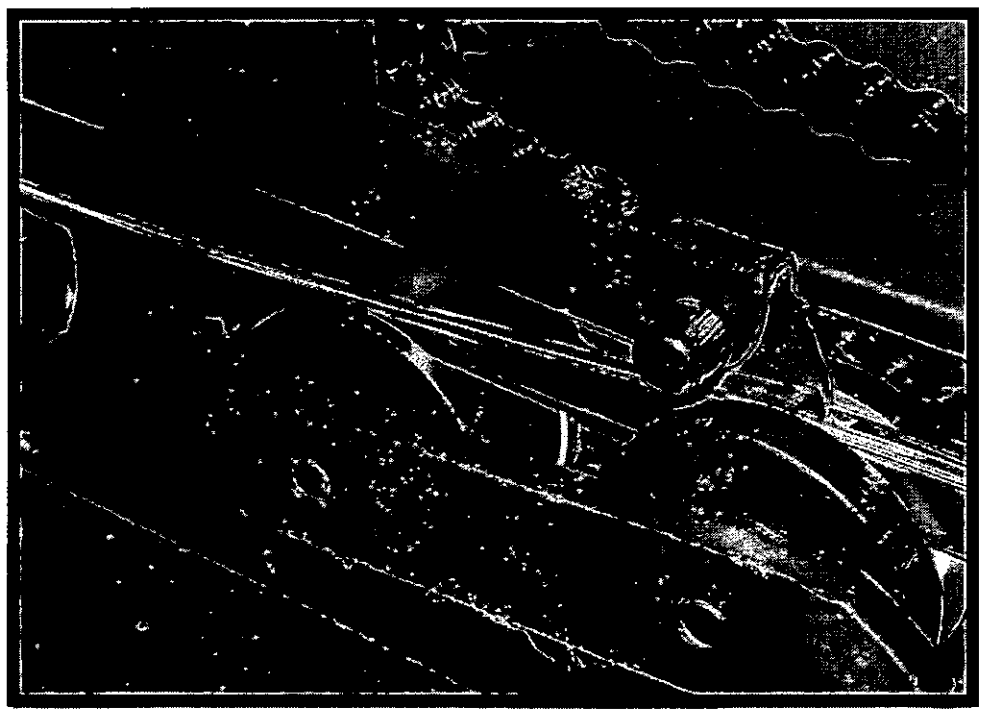
Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Máquina de Tubos



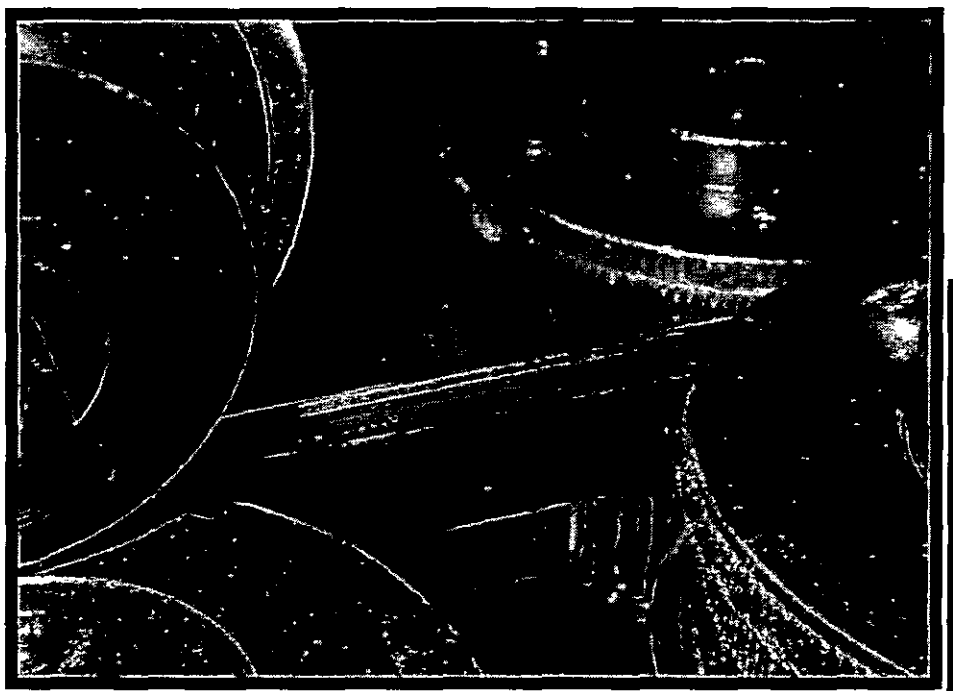
Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Máquina de Tubos



Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

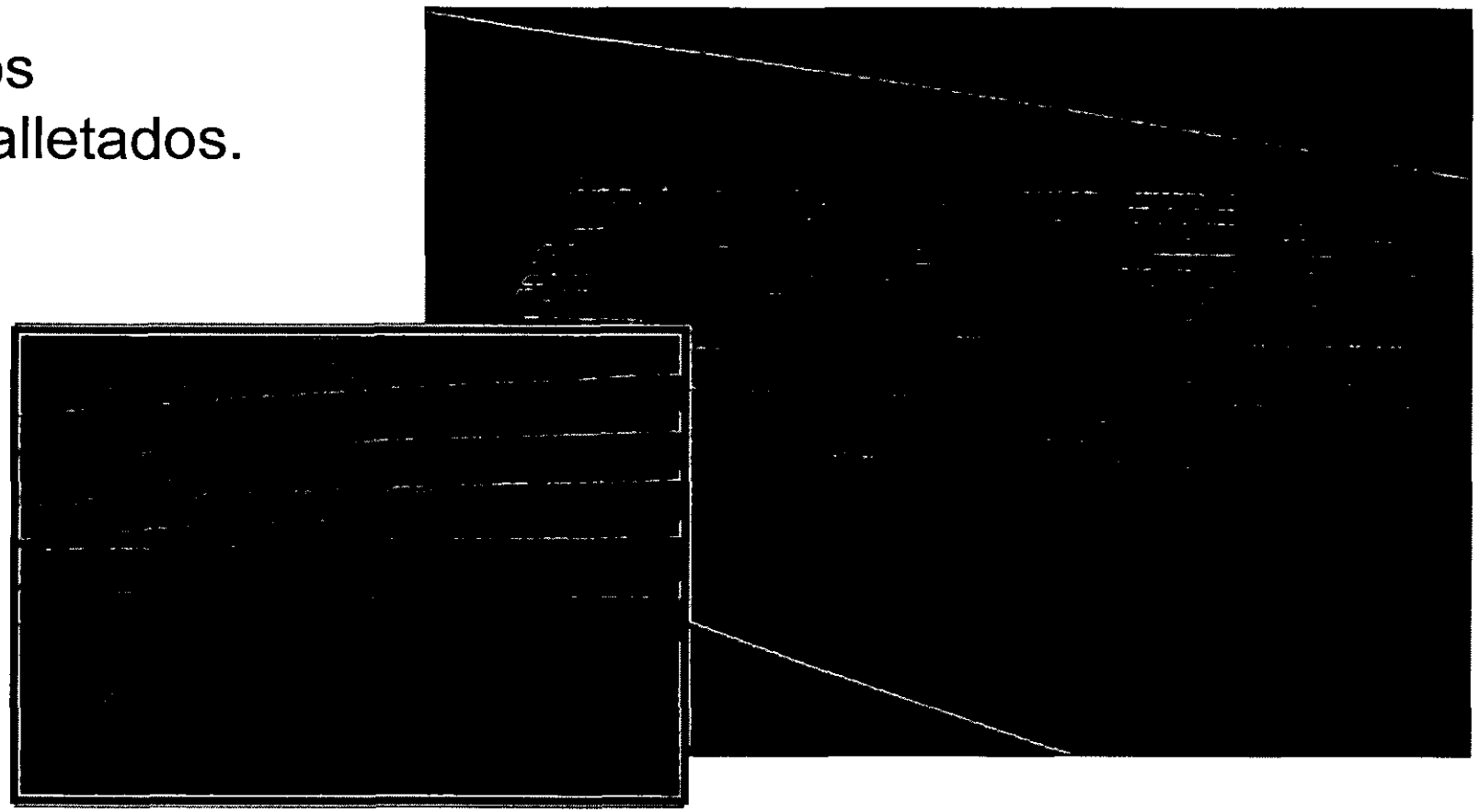
Máquina de Tubos



Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Tubos emballetados

Tubos emballetados.

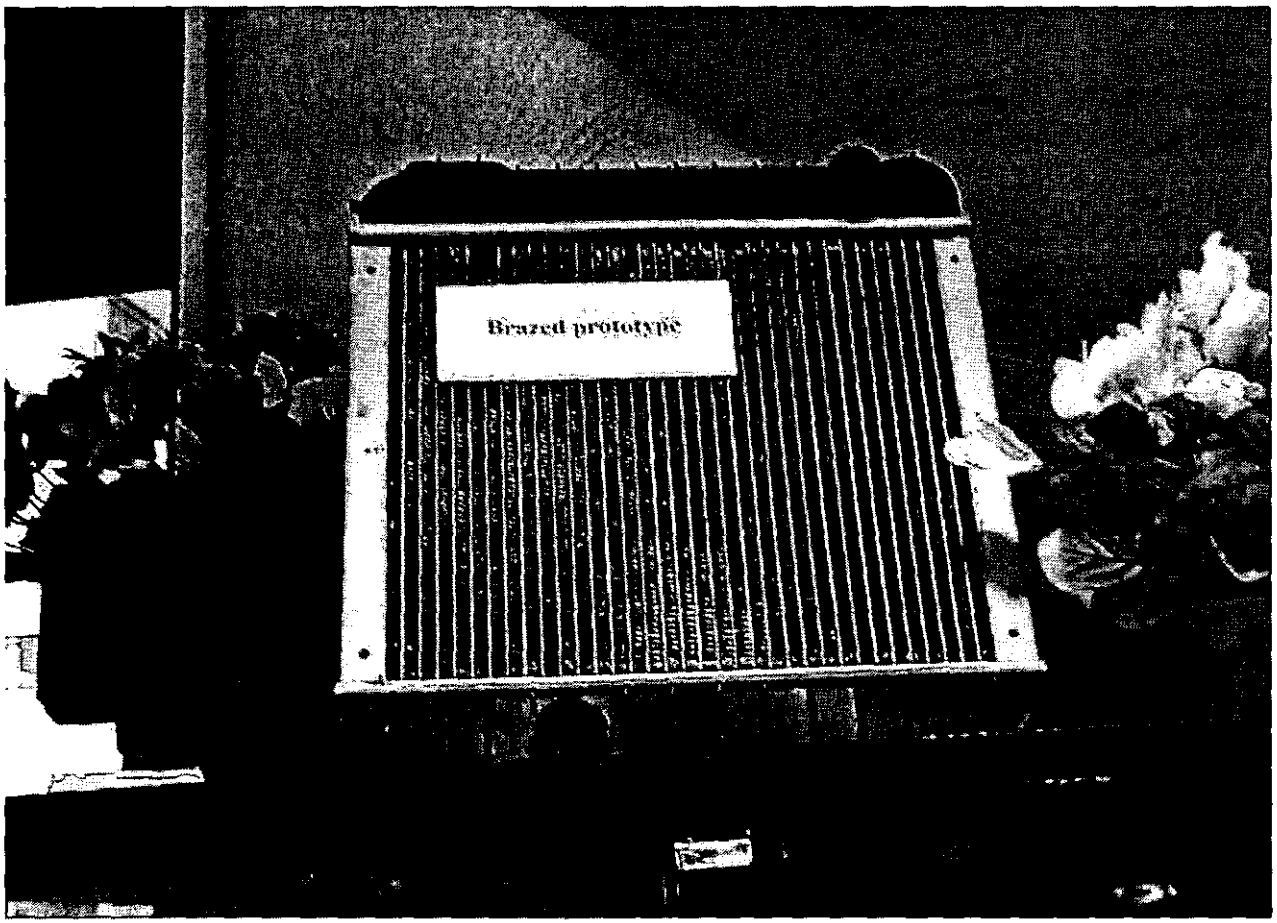


Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Transferencia Tecnológica

- Visita Rodrigo Gallardo Díaz, a Centro Técnico y Planta Piloto Cuprobraze en Outokumpu, Suecia.
- Vaasteras, Finspong.
- Junio, Año 2001.

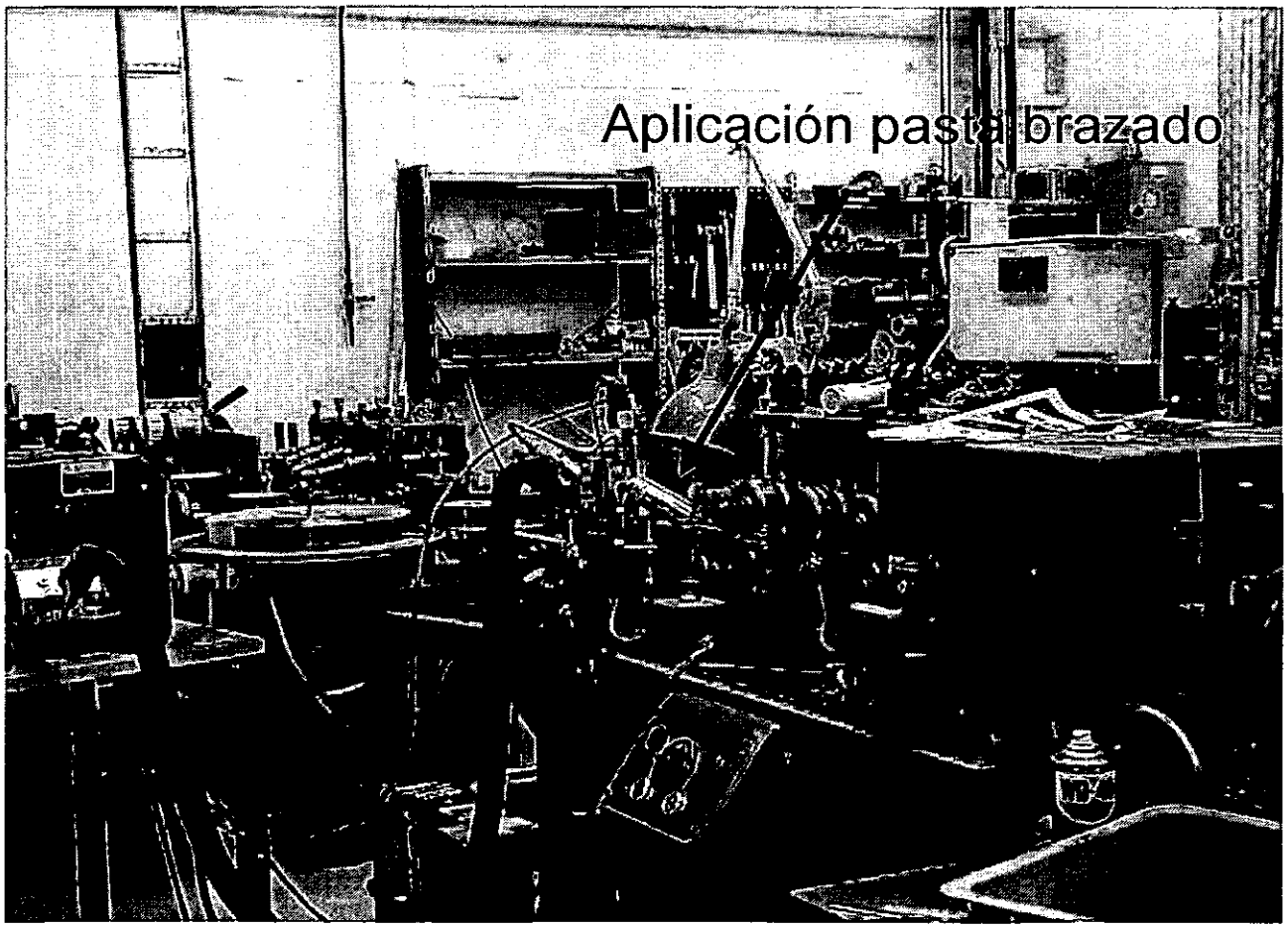
Outokumpu - Centro Técnico, Vaasteras, Suecia.



Radiador Prototipo Cuprobraze

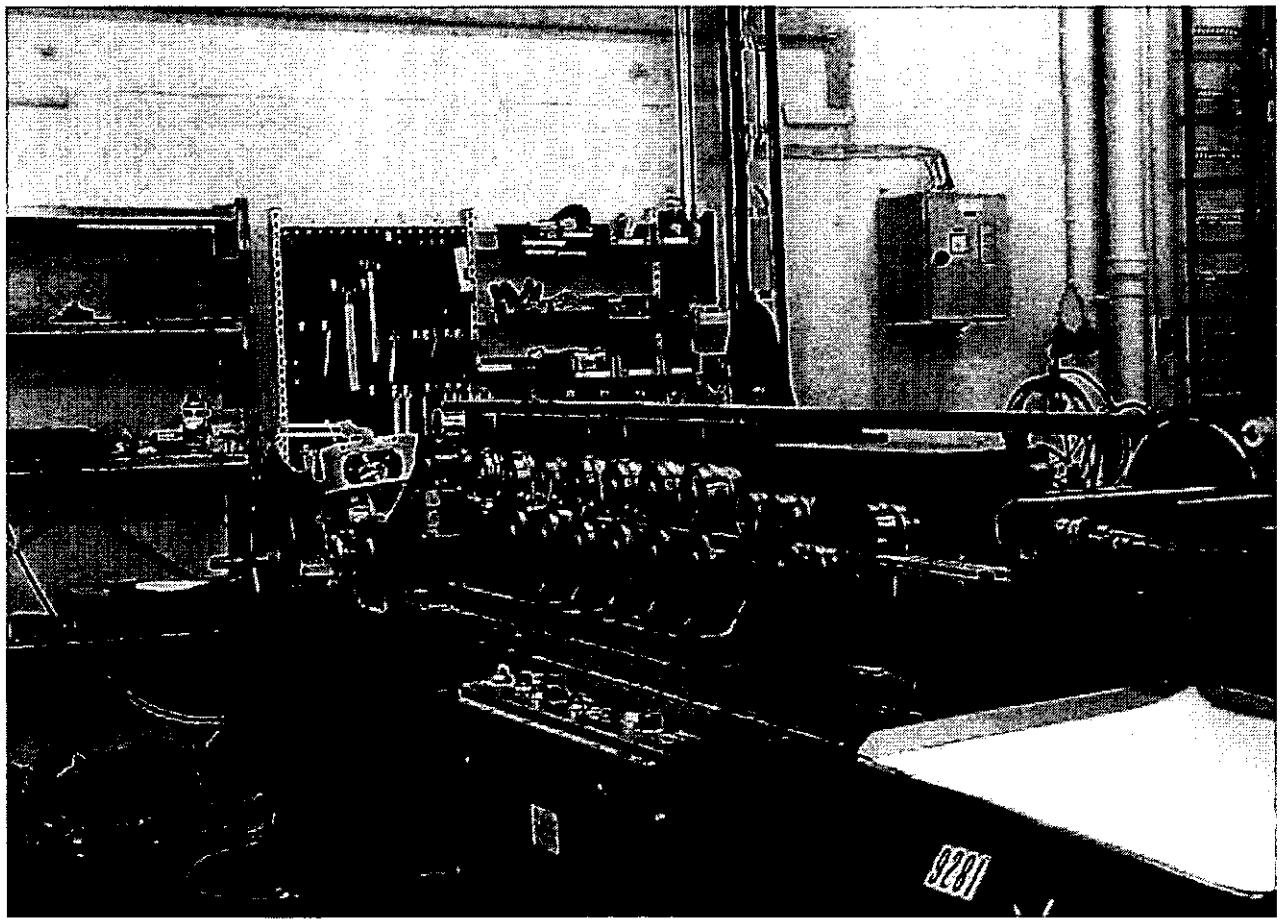
Outokumpu - Centro Técnico, Vaasteras, Suecia.

Tubera para tubos emballetados y aplicación de Pasta de Brazado en el emballetado.



Outokumpu - Centro Técnico, Vaasteras, Suecia.

Tubera para tubos Sin costura.

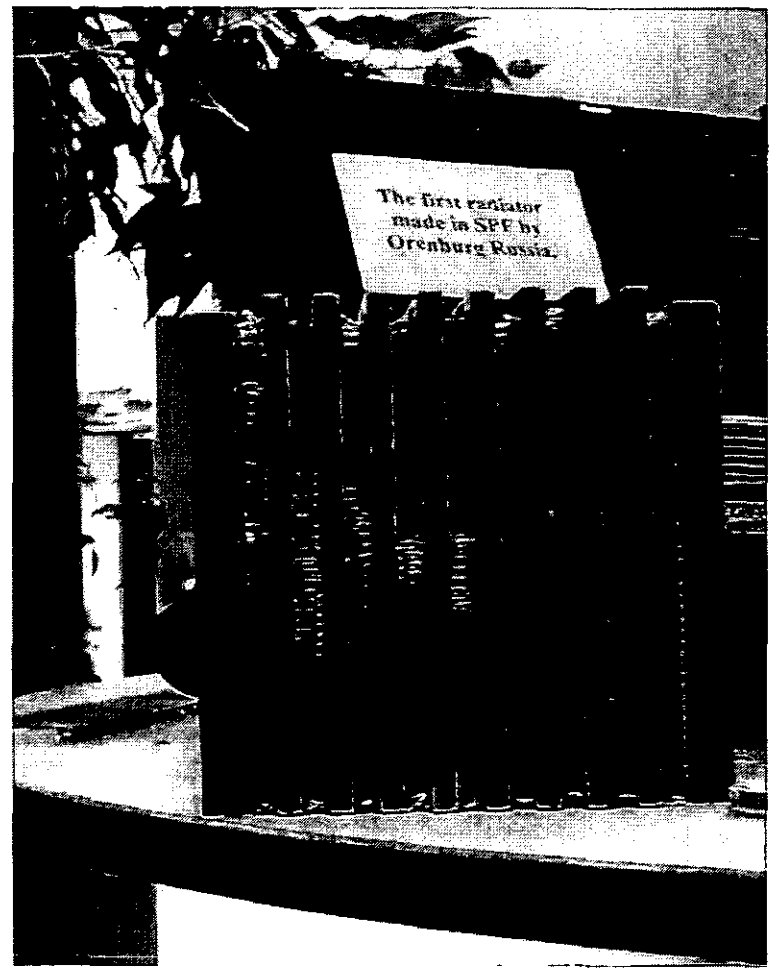


Outokumpu - Centro Técnico, Vaasteras, Suecia.

Panal Prototipo para fabricación de Charge Air Coolers, enfriadores de Aire de Los Turbos, en Cobre con Tecnología Cuprobraze.

Actualmente el panal es fabricado en Aluminio con tecnología Nocolok y Aluminio Brazado y Ambos Estanques en Alumino Fundido.

Los CAC conocidos como Intercooler son utilizados en Camiones y Buses principalmente.

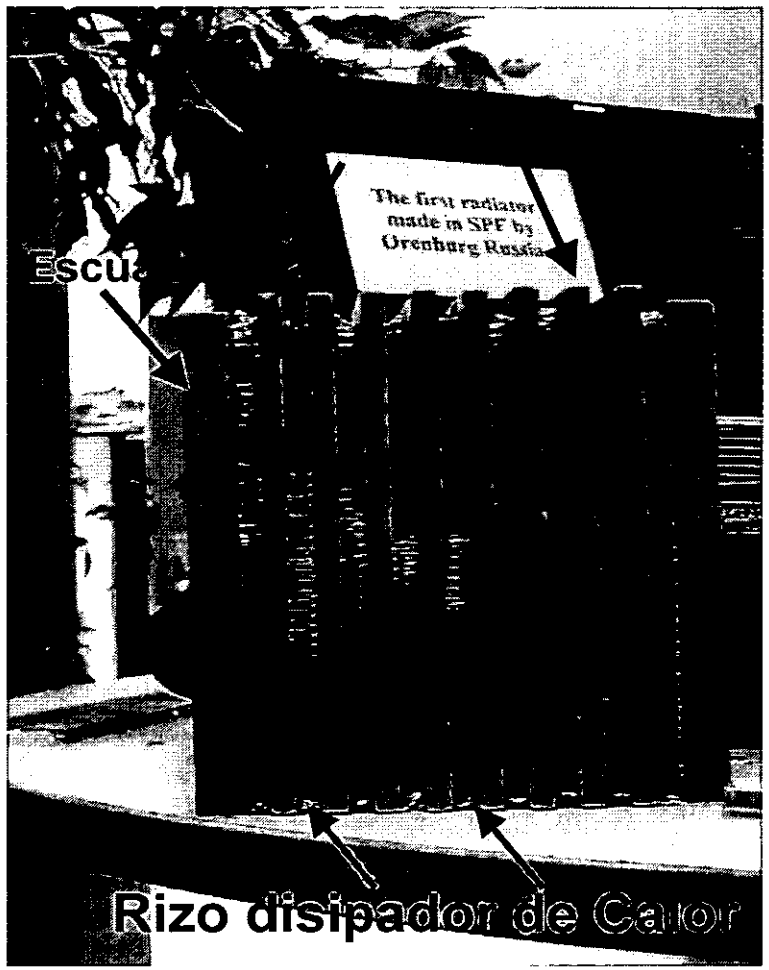


Outokumpu - Centro Técnico, Vaasteras, Suecia.

El tubo es armado a partir de dos L en plancha de 0,8 mm de espesor.

En su interior se inserta un Rizo para retención del Aire, caída de presión necesaria y mayor área de transferencia en contacto con el aire.

Escuadras en Planchas de 1,0 mm de espesor.



Outokumpu - Finspang, Suecia.

- La Tecnología CuproBraze está en una etapa Experimental avanzada y de Introducción a varios fabricantes del Mundo.
- Tanto Outokumpu como varios fabricantes están experimentando y desarrollando prototipos para aplicaciones Industriales como enfriadores de aceite e intercoolers.

BIBLIOTECA CORFO

Outokumpu - Finspang, Suecia.

- En Radiadores hay dos mercados : a) OEM y b) Aftermarket.
- Inicialmente se quería el uso de esta tecnología en OEM, Original equipment manufacture (Fabricantes de Automoviles)
- Este mercado es dominado por pocas empresas en el mundo, las que no quisieron adoptar inicialmente la tecnología Cuprobraze.

Outokumpu - Finspang, Suecia.

- Al Orientarse al mercado Aftermarket (Mercado de Reposición), fábricas como las nuestras pueden entrar en el proyecto.
- En esta etapa los fabricante OEM están experimentando con la tecnología y en etapa de desarrollo de futuros modelos para automóviles nuevos.

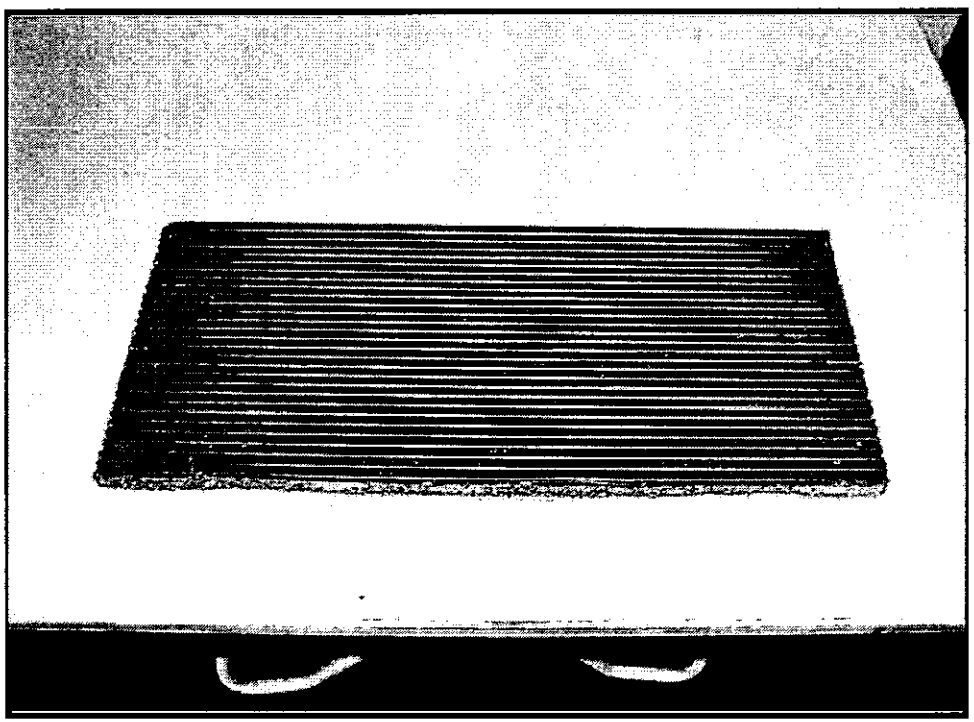
Outokumpu - Finspang, Suecia.

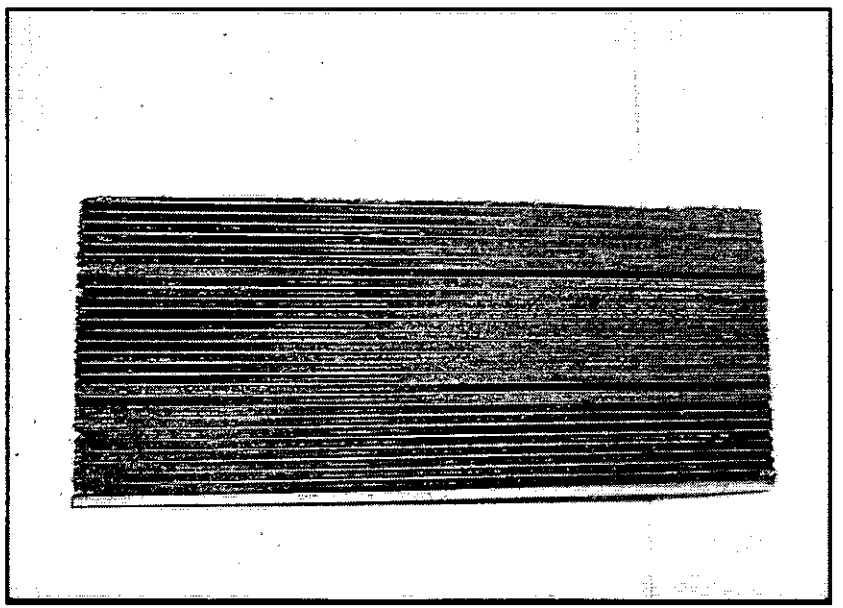
- La tecnología fue concebida pensando para la fabricación de Radiadores.
- Pero con el tiempo se ha manifestado un alto interés de parte de los fabricantes en el usos de esta tecnología en Intercooler y Enfriadores de Aceite industriales.

Radiadores Gallardo Laporte S.A.

- Prototipo Panal Automotriz
- Prototipo Enfriador de Aceite Industrial.

Prototipo Panal Automotriz

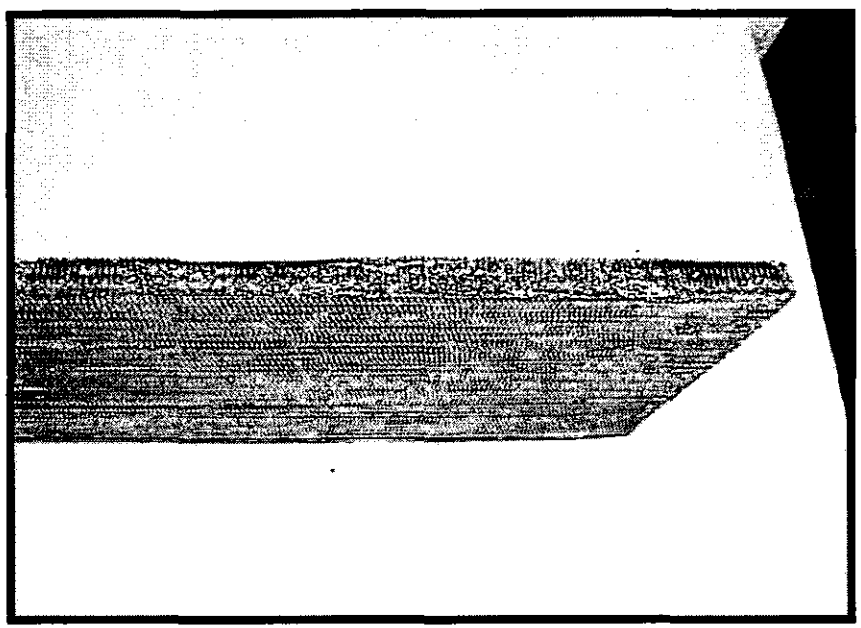


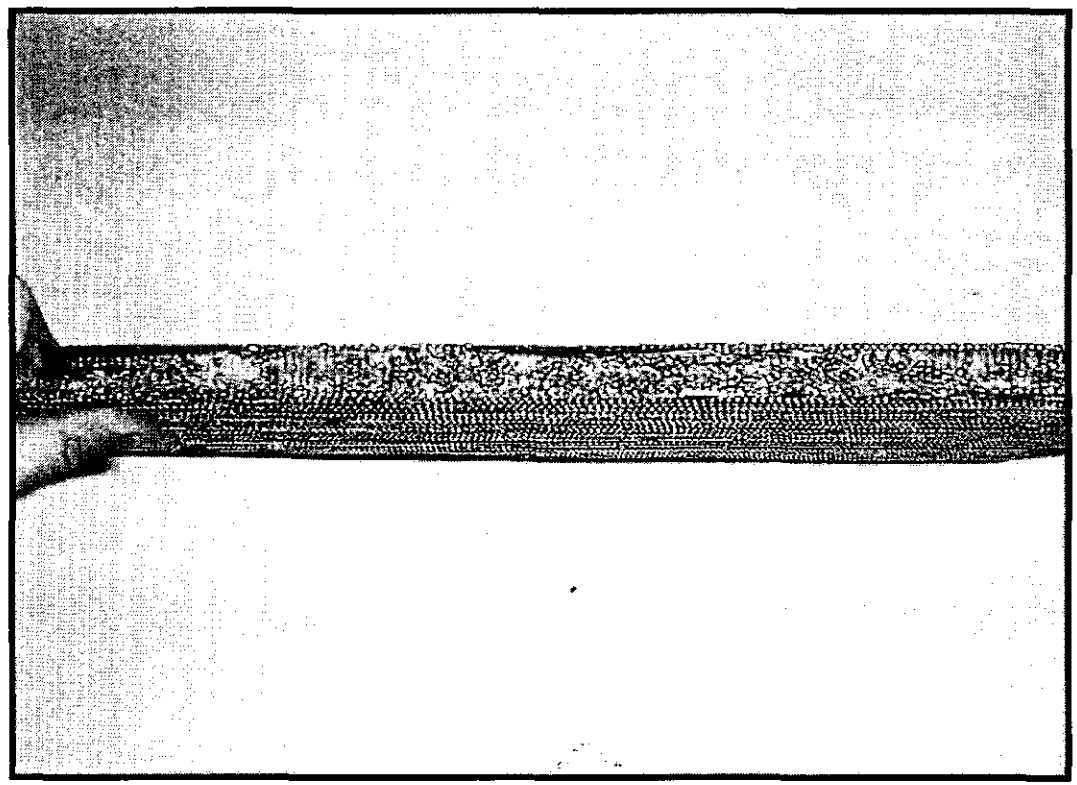


Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Prototipo Panal Automotriz

Pruebas de
Adherencia

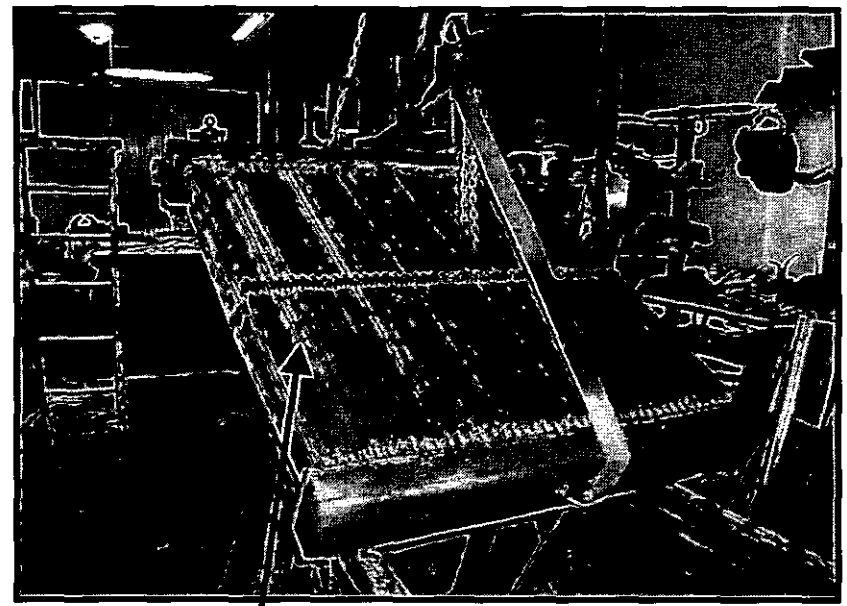


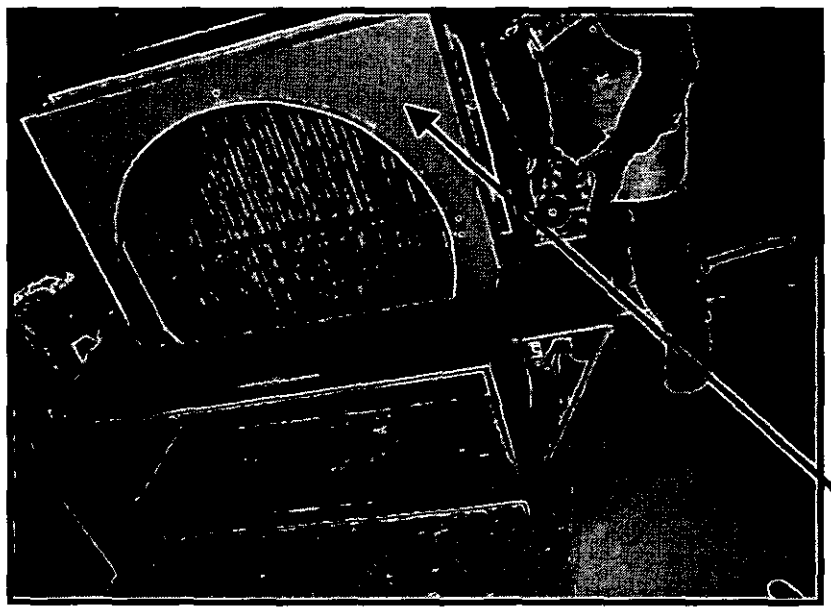


Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Prototipo Enfriador de Aceite Industrial

Proceso de Fabricación de Prototipo.





Panal y Estanques Enfriador de Aceite

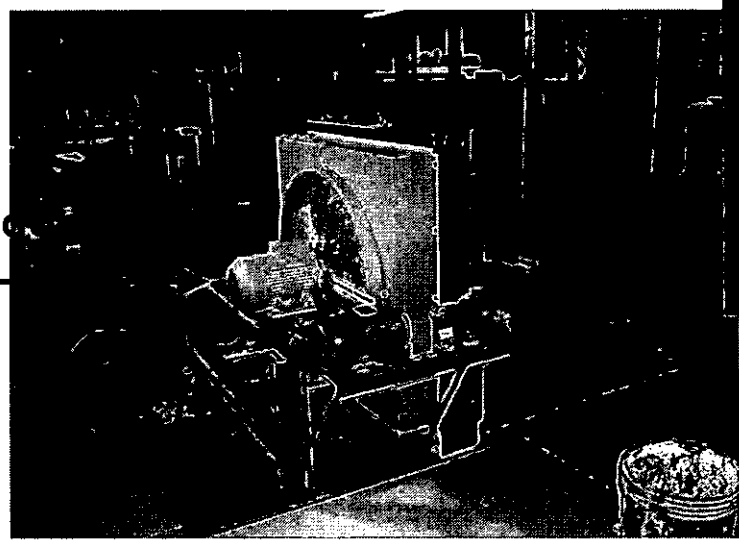
Embudo

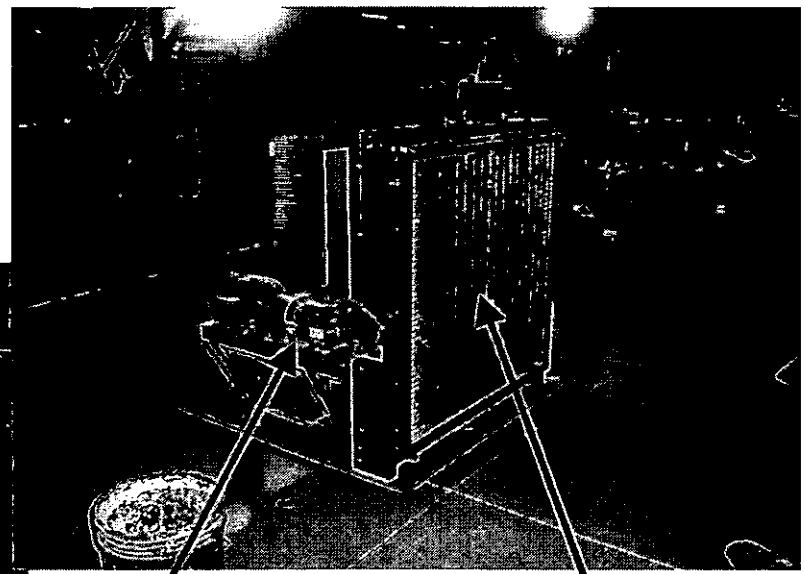
Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

Prototipo Enfriador de Aceite Industrial

Prototipo enfriador de Aceite/Aire.

Diseñado bajo Normas Ambientales de Emisión de Ruidos, Polvo y Reciclaje del equipo.





Motor y Ventilad

Bomba de Aceite

Filtro y Malla Protectora

Radiadores Gallardo Laporte S.A. - Proyecto Cuprobraze

D) Resultados Obtenidos y Conclusiones

- Se produce Transferencia Tecnológica de Outokumpu a Radiadores Gallardo Laporte S.A.
- La tecnología Cuprobraze presenta un gran potencial y cuenta con el respaldo de Outokumpu y otros productores mundiales de Cobre. Ademas de ICA. El objetivo final es recuperar terreno perdido con el Aluminio.

D) Resultados Obtenidos y Conclusiones

- La tecnología Cuprobraze esta todavía en etapa experimental.
- Se está buscando experimentar en otros usos como los Charge Air Coolers.
- Se tiene un cabal conocimiento de la tecnología Cuprobraze, su estado de desarrollo y portencial.

D) Resultados Obtenidos y Conclusiones

- Se fabricó maquinaria para la construcción de procesos y productos piloto.
- Nuestro proceso de Innovación está siendo observado y apoyado por Outokumpu quien durante este año visitará nuestra Planta (Kurt Svanberg, Manager Technical Center) .

D) Resultados Obtenidos y Conclusiones

- La tecnología Cuprobraze todavía no es 100% comercializable en el muy Corto Plazo, pero su potencial es enorme, sobretodo por el hecho de ser un proceso amistoso con el medio ambiente.
- Radiadores Gallardo Laporte S.A. Cree que esta variable dejará en un futuro cercano fuera muchos procesos en el mercado mundial.

D) Resultados Obtenidos y Conclusiones

- Se fabricó un prototipo de Panal Automotriz con resultados positivos.

- Se fabricó un prototipo de Enfriador de Aceite Industrial para aplicaciones hasta 100 psi, con resultados positivos.

D) Resultados Obtenidos y Conclusiones

- Se fabricará un prototipo desarrollando Charge Air Cooler en Cobre (Actualmente son en Aluminio), el que será evaluado por Outokumpu.
- Se seguirá investigando para desarrollar un prototipo de enfriadores de aceite para presiones de trabajo mayor a 100 psi y hasta 350 psi.

D) Impactos del Proyecto

- Se tiene acceso a nueva tecnología para la fabricación de Radiadores en Cuprobraze.
- Se tiene acceso a uso del centro Técnico de Outokumpu. Esto implica trasferencia tecnológica permanente, asistencia técnica, acceso a sus laboratorios, uso de maquinaria para construcción de prototipos y uso de tunel de viento para evaluación de productos.

D) Impactos del Proyecto

- Se desarrollo prototipo de Enfriador de Aceite para aplicaciones industriales sometidas a presiones de hasta 100 psi.
- Estos enfriadores son fabricados en el mundo en Aluminio brazado o Nocolok, presentando excelentes resultados en términos de transferencia de calor, pero su durabilidad en ambientes agresivos es muy baja por la alta corrosión que sufren.
- Lo anterior hace que su performance en aplicaciones mineras en Chile sea deficiente.

BIBLIOTECA CORFO

D) Impactos del Proyecto

- El potencial de sustitución de importación de este tipo de productos es de sumo interés.
- Actualmente se fabrican estos enfriadores en Chile con Tubos o Cañerías de Cobre y Láminas de Aluminio. Su unión es por proceso de expandido. En algunos casos se usan láminas de Cobre.
- El performance de estos equipos es bajo, y no se alcanzan las eficiencias de los equipos de aluminio en el espacio solicitado.

D) Impactos del Proyecto

- El acceso a esta tecnología permite evaluar la posibilidad de incorporarla a escala productiva nacional, ya que la tecnología equivalente en aluminio es de inversiones de aproximadamente us$ 8.000.000.- y estimamos que la tecnología cuprobraze se podría implementar con una inversión de us$ 300.000.-

D) Impactos del Proyecto

- La Tecnología Cuprobraze es amistosa con el medio ambiente, por lo que un producto fabricado con esta tecnología puede ser exportado a cualquier país del mundo.

F) Anexos

- Informe Financiero
- CuproBraze, Manual Técnico.
- Outokumpu, Literatura, Charge Air Cooler y Enfriador de Aceite Desarrollado en Japón.

F) Anexos

- CuproBraze, Manual Técnico.

*Cu*proBraze®

TECHNICAL MANUAL

outokumpu

February 2000

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BIBLIOTECA CORFO

1. General

The *Cu*proBraze® process is a brazing process specifically developed for the manufacturing of automotive and heavy duty industrial heat exchangers.

By using high strength and high conductivity copper and copper alloys it is possible to manufacture light, strong, efficient and compact heat exchangers at a low cost with this environmentally friendly process.

1.1 Brazing theory

Soldering and brazing involve the same bonding mechanism. Soldering is defined as using filler metals with melting temperatures below 450 °C (840 °F). Brazing is defined by the use of filler metals that have melting temperatures higher than the above temperature limit.

In both soldering and brazing the bonding mechanism is a reaction between the brazing alloy and the parent metal. Usually it results in alloying, to form a metallic bond at the interface.

The filler metal flows into the joint gap by capillary force and forms a bond. Joint clearance and geometry have several effects on the mechanical performance of the finished joint. Those include the purely mechanical effect of restrain to plastic flow of the filler metal, offered by the greater strength of the base metal, the possibility of slag entrapment, the possibility of void forming and the relationship between the joint gap width and capillary force which accounts for filler metal distribution.

In both soldering and brazing interactions between the filler metal and the base metal take place. Due to the higher temperature, the interactions are sometimes heavier in brazing. The interactions are time and temperature dependent, and to minimize the interactions the brazing temperature should be as low as possible and the time at brazing temperature as short as possible.

2. Copper alloys

The brazing temperature is higher than the softening temperatures for the conventional copper alloys used in soft soldered radiators. Therefore, special copper alloys have been developed for brazed radiators and it is necessary to use those alloys.

The tube material is a CuZn15 brass with about 1 % additional alloying elements to prevent softening of the material during the brazing operation. Typical material properties are shown in table 1 and 2.

The copper fin alloy is of dispersion hardening type, which means that precipitates prevent the material from softening. The high conductivity is reached during the brazing operation.

Table 1. Mechanical properties of Outokumpu's copper and brass materials for CuproBraze®.

Properties	Unit	Fin Copper SM 0502		Tube Brass SM 2385		Header* SM 2464
		Bef. brazing	After brazing	Bef. brazing	After brazing	
Conductivity	% IACS	60	94	35	30	
Yield Strength	N/mm^2 (ksi)	340 (49)	260 (38)	340 (49)	270 (39)	115 (17)
Tensile Strength	N/mm^2 (ksi)	400 (58)	330 (48)	420 (61)	400 (58)	350 (50)
Hardness	HV	120	105	130	115	70
Elongation A_{50}	%	1	10	25	30	70

* For header + side support, CuZn36Ni3 type

Table 2. Physical properties of Outokumpu's fin copper and tube brass for CuproBraze®.

Physical Properties	Unit	Fin Copper SM 0502	TubeBrass SM 2385
Density	g/cm^3 (lb/in^3)	8.90 (0.321)	8.75 (0.316)
Melting Temperature	°C (°F)	1083 (1981)	1000-1025 (1832-1877)
Specific Heat	kJ/kg°C (BTU/lb°F)	0.385 (0.092)	0.380 (0.091)
Thermal Expansion 20-300°C (68-572°F)	$°C^{-1}$ ($°F^{-1}$)	$17.7 \cdot 10^{-6}$ ($9.8 \cdot 10^{-6}$)	$19 \cdot 10^{-6}$ ($10.6 \cdot 10^{-6}$)
Mod. of Elasticity	N/mm^2 (ksi)	118 000 (17 093)	122 000 (17 673)

3. Brazing powder

3.1 Basic alloy

Figure 1 shows the principal braze alloy families and the corresponding melting ranges. Observe: Cadmium containing metal filler should not be used due to toxicity.

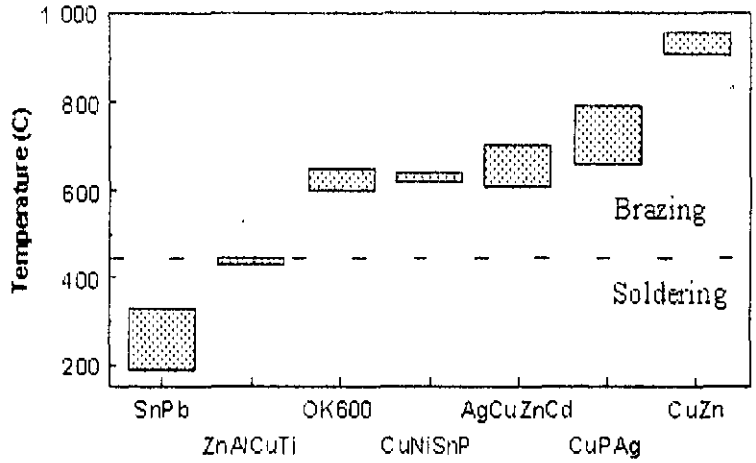

Figure 1. Soldering and brazing alloy families and their melting ranges.

The CuNiSnP-family group includes the brazing filler metal developed for brazing of radiators. This filler metal is called OKC 600 with compositions shown in Table 3.

Table 3. The composition of OKC600 brazing powder. The alloy has been patented (US-patent 5 378 294) by Outokumpu but can be freely used for automotive and heavy duty industrial heat exchanger applications. Melting temperature is 600 °C and melting range 10 °C.

Element	Quantity, %
Nickel, Ni	1 to 5
Tin, Sn	15 to 20
Phosphorus, P	4 to 7
Copper, Cu	Balance

3.2 Powder

The brazing filler metal is produced by gas-atomizing to spherical fine grained powder. The maximum particle size is 90 µm, (3.5 mils), and average particle size is 15 to 30 µm (0.6 to 1.2 mils), depending on source. Follow carefully the storing instructions shown on the package and/or data sheet. In case the powder oxidizes during storing, it can be reconditioned by powder manufacturers.

During year 2000 production licenses will be granted to qualified powder producers in America, Europe and Asia. The competition will bring down the purchase cost of the powder gradually to a very reasonable level.

3.3. Pastes by Degussa-Hüls AG

Contact

Degussa-Hüls AG
Precious Metals Division
Business Unit Technical Materials

Mr. Helmut Klosterbecker
Manager of Customer Service - Brazing Technology

Rodenbacher Chaussee 4
P.O. Box 1345
D-63403 Hanau (-Wolfgang)
Germany

Telephone +49 6181 59 2623
Telefax +49 6181 59 4893
E-mail: helmut.klosterbecker@degussa.de

BrazeSkin SCu200: Water based paste

Application: Tube coating.

Two components paste to be mixed by the customer (powder 80% - binder 20%) on the spot. The powder has a tendency to oxidize when mixed with the binder and can therefore only be stored for a very limited period of time. Packaging in 25 kg drums (powder) and 10 kg drums (binder).

Viscosity	adjustable to application technique
Specific density	3-4 g/cm^3
Drying temperature	100-120 °C

BrazeSkin DCu200: Solvent based brazing paste

Application: Tube to header joint.

The paste has to be mixed with alcohol by the customer. Packaging in 25 kg drums.

BrazeSkin RCu200: Thermoplastic brazing paste (Old designation: P088)

Application: Fin tip coating.

Applied by roller coating method. Packaging in 5 kg plastic tubes.

Metal content	85 to 95%
Viscosity	5 to 10 Pas (depending on temperature)
Specific density	4 to 5.5 g/cm^3
Softening temperature	45 to 65 °C
Melting temperature	> 70 °C

Solvent emission	0 Vol-%
Shelf life	6 months

MSDS's (Materials Safety Data Sheets) of all products are available at the producer.

3.4 Pastes by OMG Americas

Contacts

OMG Americas

Gary Cowan

Manager, International Sales

Anil V. Nadkarni

Director

2601 Weck Drive

P.O. Box 12166

Research Triangle Park, NC 27709-2166, USA

Tel: +1 919 544 8090
Fax: +1 919 544 7996

E-mail: gary.cowan@omgi.com or
anil.nadkarni@omgi.com

Thermoplastic TP100 Series

Applications: Tube coating.

Brazing alloy powder + thermoplastic binder. Applied by dipping in a molten pool or by hot spraying. Solidifies quickly to a hard adherent coating.

Metal content	85 to 95%
Melting temperature	55 °C (130 °F)

Thermoplastic TP200 Series

Applications: Fin tip coating.

Brazing alloy powder + thermoplastic binder. Applied by using fin tip coating machine or by dipping. Solidifies quickly to a smooth, tough coating.

Metal content	85 to 95%
Melting temperature	75 °C (165 °F)

Slurry SL100 Series

Applications: Tube to header or tube coating.

Brazing alloy powder + solvent + binder designed for coating header. Applied by slurrying or spraying.

Metal content	85 to 95%

MSDS's (Materials Safety Data Sheets) of all products are available at the producer.

3.5 Others

There are also other companies developing pastes. One of them very close to commercialisation of their products is Lucas-Milhaupt in USA. Contact person is Nitin Shah, e-mail: lucas_mil04@earthlink.net.

4. Paste application

For tube/fin joints the brazing paste is applied, alternatively, on the tube surfaces or on the fin tips. Normally, no precleaning is necessary.

4.1 Tube spraying

The paste is applied on the tube surfaces usually by spraying with a spray gun. Water-based paste is normally used for radiators with corrugated fins and harder solvent based paste for flat fin push-tube radiators. Suitable spray guns exist in the market. After spraying the coating is dried using hot air. The drying is complete when the coating is free from water or solvent.

It is important that the coating is not overheated. When the coating becomes brownish it has been destroyed.

The coating thickness is measured by weighing. The recommended quantity is typically 150 to 200 g/m^2 of tube surface area. A thicker coating can compensate for wider tolerances of the fins.

Machine deliveries by Schöler GmbH, Frankfurter Strasse 4-6, D-23689 Pansdorf, Germany. Tel. +49 4504 6010, Fax +49 4504 601 133, e-mail: sale@schoeler.de. Website: www.schoeler.de Contact: Jan Schöler.

4.2 Fin tip coating

The principle of the fin tip coating application is that the fin tips are brought in contact with warm thermoplastic paste with a certain thickness on roll surfaces. After passing the gap between two rolls and cooling down the fin tips have a coating of solid thermoplastic paste.

One type of application method is shown in figure 2. The warm thermoplastic paste is applied on warm rotating rolls and the paste layer thickness is adjusted with scrapers. The

roll speed and the pressure on the scrapers will adjust the thickness of the paste layer. It is important that both the rolls and the paste are at the same temperature in the range for the lowest viscosity of the paste, e.g. 100 to 130 ° C (212 to 226 ° F).

For small prototypes the fin tip coating can be arranged by using a hot plain metal sheet on which the paste is applied.

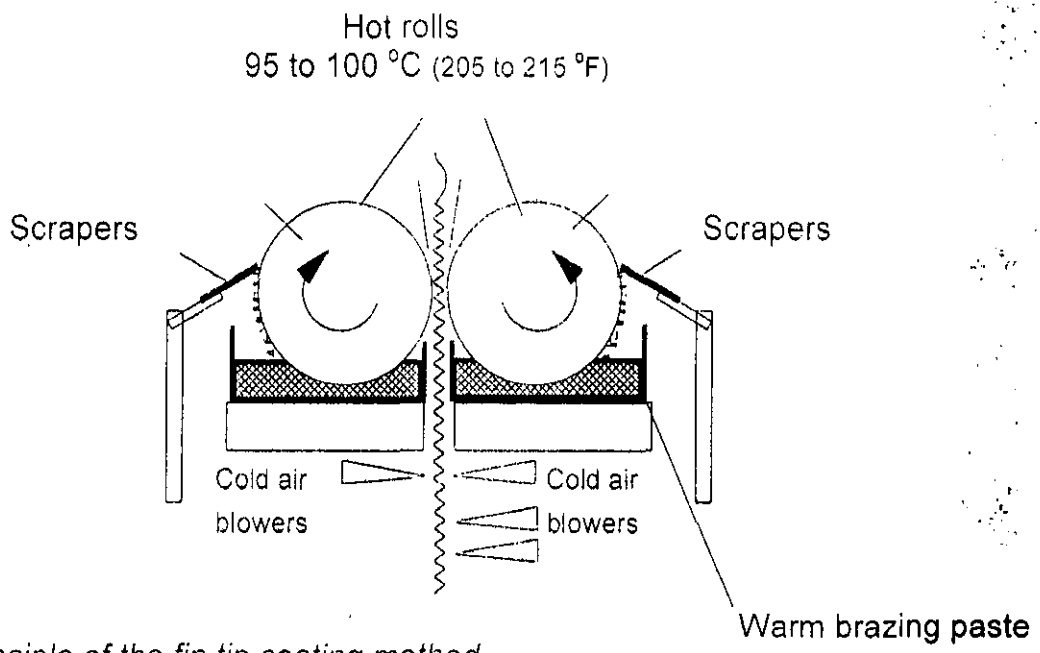

Fig. 2. Principle of the fin tip coating method .

NOTE: Above 130 °C (226 °F) the brazing properties of the paste will be destroyed.

The amount of paste is measured by weighing. The recommended amount of paste is 0.3 to 0.5 mg/mm fin tip width ($2.7 \cdot 10^{-4}$ to $4.5 \cdot 10^{-4}$ oz/in). The smallest quantity is for fins with best tolerances.

Machine deliveries by Schöler GmbH, Germany, see 4.1 for contact information.

4.3 Tube to header joint

The most critical braze joint of the radiator is the tube/header joint as it has to be totally leak free. It is thus imperative that enough braze material is in place when brazing takes place.

A dedicated slurry is used for tube/header joints. The slurry is a mix of powder, binder and solvent. It can be applied by pouring or spraying.

Both methods are very well suited for automation and if the header design is right it also gives low braze material consumption.

5. Components and assembling

A brazing operation requires better defined joints than soft soldering. Generally, closer tolerances and well defined joint gaps result in better and stronger joints.

Another aspect to take into account is that the brazing alloy is in powder form and will build up a thicker layer than a solid metal. The geometry of the tubes and fins and the tube pitch in the header have to be adjusted accordingly.

5.1 Tubes

High frequency (HF) welded tubes are easiest to use for *Cu*proBraze® radiators because their shape is well controlled and they form a defined gap between the tube and the header. The HF-tube mill is relatively expensive and the wall gauge is limited to min 0.12 mm (0.005"). HF-tubes are, however, sold commercially. Main suppliers of *Cu*proBraze® tubes are are Arzon Ltd in Canada , Thermal Components (TCI) and Hot & Cool in the USA, see contact information below.

Arzon Ltd Mr. Jeff Carrubba 85 Burford Road Hamilton, Ontario Canada L8E 3C6 Tel: +1 905-561-2424 Fax: +1 905-561-2362 Internet: www.arzonlimited.com E-mail: info@arzonlimited.com	**Thermal Components** Mr. Webb Cowden 2760 Gunther Park Drive West, P.O. Box 3253 Montgomery, Alabama 36109, USA Tel: +1 334 277 1810 Fax: +1 334 271 4210 E-mail: wcowden@thermalgroup.com	**Hot & Cool Tubes** Mr. Dick Thrasher 83 Woodrock Road, Weymouth, Massachusetts 02189, USA Tel: +1 781 335-5164 Fax: +1 781 331-9276

Lock-seam tubes are used in a majority of soft soldered radiators. They are manufactured in lower cost machines of thinner brass strips, thicknesses down to 0.085 mm (0.003"). Development of lock-seam tubes for *Cu*proBraze® is underway.

Laser welding of thin gauge flat oval tubes is a new development that combines the well defined shape of a HF-welded tube and the ability to use thin material < 0.1 mm (0.004"). Laser-welding machines for radiator tubes can be purchased from Schöler GmbH in Germany (see 4.1. for contact info).

For *Cu*proBraze® process it is recommended to specify tubes with higher crown than for soft soldering. It has been found that it gives a more consistent bond between tube and fin. The crown, C, should be 0.2 to 0.4 mm (0.008" to 0.016 "), for tube widths of 12 to 25 mm (0.47 to 1.0").

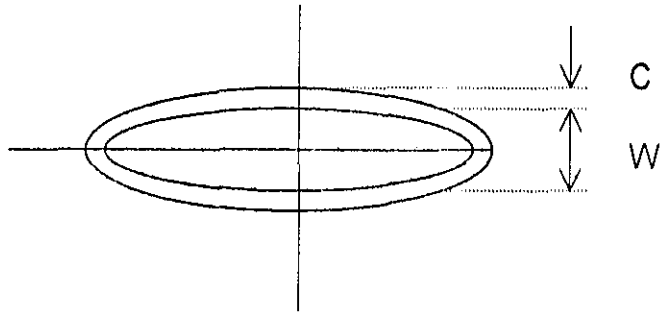

Fig. 3. CuproBraze® process needs tubes with higher crown (c) than soldering process.

5.2 Fin

The main dimension that influences this process is the fin amplitude. The more consistent the better the brazing result. Thinner layers of braze material can be applied, which is good both from technical and economic point of view.

In tube coating method, the variation from fin tip to fin tip of less than 0.050 mm (0.002 ") is recommended.

If the brazing alloy is applied by fin tip coating it is also important that each fin tip is straight and has consistent fin amplitude. If not, there is a risk that the fin will be deformed and the braze material will be applied in an uneven layer. Also here the variation should be kept within 0.050 mm (0.002 ").

5.3 Header

The major design feature, that influences the brazing, is the formation of the holes in the header. These holes can be designed and manufactured in different ways, see Fig. 4.

Fig. 4. Header manufacturing methods. Pierced holes (left and middle) are recommended. Lanced holes (right) are used for soft soldering and are not recommended for brazing.

For the *Cu*proBraze® process it is recommended to use pierced holes, as these joints give a far better fit to the tubes. The pierced holes should provide a radial braze gap of 0.05 mm (0.002 ") between tube and header.

5.4 Core building and fixturing

As earlier mentioned, the brazing powder builds up a thicker layer than a solid metal layer. This has to be taken into account when the tube size, fin amplitude and tube pitch in the header are determined.

The tube pitch is made up of nominal fin and tube dimensions. As tube dimension widens corrections might be needed like reducing fin height at given tube pitch or vice versa.

After assembling the cores should have more or less pronounced barrel shape, depending on the core size. The fixturing has to be adjusted accordingly.

6. Brazing Operation

The temperature of *Cu*proBraze® brazing is much higher than that of the soldering process. To prevent oxidation, to both the parent and filler materials, we need to join the metals in an inert atmosphere. In order to select a suitable furnace we must know the temperature, time and atmospheric conditions required for the process.

6.1 General Furnace Parameters

Furnaces suitable for the *Cu*proBraze process must have the following characteristics.

6.1.1 Atmosphere

The primary function of the brazing atmosphere is to prevent oxidation. Furnaces today use high purity nitrogen to displace oxygen from inside the furnace.

The atmosphere of the furnace must have a dew point of less than –40 °C and an oxygen content of less than 20 ppm. To achieve this very good atmosphere, nitrogen gas with a dew point of – 65 °C and an oxygen content of less than 10 ppm is used successfully today.

If moisture and oxygen levels are higher than these levels the powder used to form the joints and the base material are oxidized and brazing becomes impossible. Therefore, the furnace must be gas tight. If there are leaks in the shell or muffle, oxygen will find a way to contaminate the brazing atmosphere.

6.1.2 Temperature and Time

The furnace must be able to heat the load between 450 °C and 650 °C with a ramp rate of > 30 °C per minute.

The furnace must be able to cool the load at a maximum of 150 °C per minute.

No heat should be applied if the atmospheric conditions are not met. The part should not leave the inert atmosphere if the part temperature is above 150 °C.

Part temperature uniformity must be within ± 7 °C.

Furnace must be able to operate at a temperature of 700 °C.

The braze filler metal starts melting when the temperature exceeds 600 °C.

The graph in Fig. 5 shows the allowable temperatures and times for a successful brazing process.

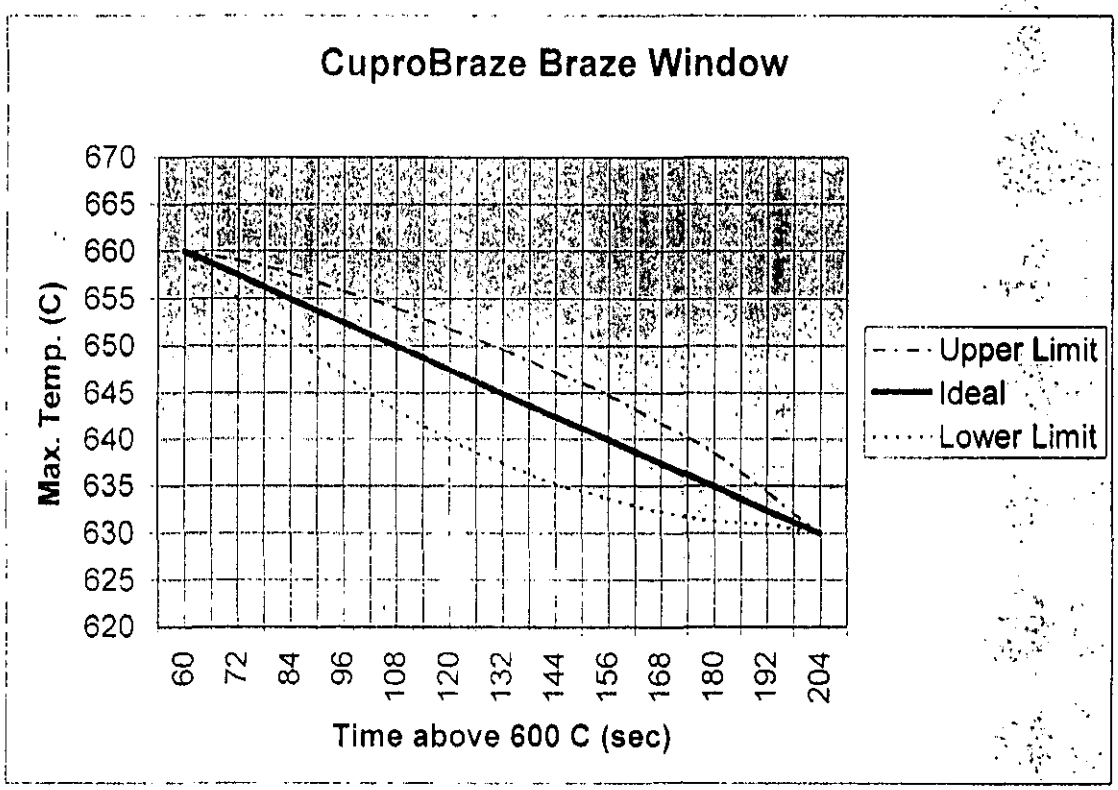

Fig. 5. Brazing operating window for succesful thermal performance result.

The heat exchanger will gradually lose thermal performance if the time above 600 °C is too long or the temperature is too high. On the other hand, the part will not braze if the time above 600 °C is too short or the temperature is too low. We must pay careful attention to the temperature profile, because the effects of a cycle that is too hot or too long can not be seen with the naked eye.

6.2 Furnace Selection

To select a suitable furnace we must first consider the following

- Production volume
- Part size
- Floor space available
- Capital expense
- Operating cost

6.2.1 Suitable Furnaces

With the specifications outlined above there are three types of furnaces suitable for the *Cu*proBraze® process

A ***batch furnace*** uses the same door to load and unload the part. These furnaces can only produce one batch at a time. A load is purged then moved into the brazing chamber. After brazing it is moved back into the purge chamber where it is cooled.

A ***semi-continuous furnace*** uses an entry and an exit door. Parts are indexed from the loading area to the purge chamber. Here the part is purged with nitrogen and then moved into the next chamber. The furnace will simultaneously move the purged part to the braze chamber and a new part into the purge chamber. It is possible to have a part in each zone of the furnace. This is for large parts or intermediate volume production.

In a ***continuous furnace*** a conveyor continuously moves parts through a furnace where they are continuously purged and brazed and then cooled. This type of furnace is for high volume production.

All the furnaces mentioned above must have a heating and cooling section. It is not acceptable to load a part into a cold furnace and heat the load and the furnace together. It is not possible to achieve the very fast heating rate required with such a furnace.

Batch furnaces and semi-continuous furnaces are suitable for any part size but are limited as regards to production volume. A continuous furnace is not recommended for parts longer than 1000 mm. When the front of the part enters the heating zone, it will immediately begin to conduct heat to the rear of the part. This means that the trailing section of the part will be at temperature for much longer than the leading edge of the part.

Furnace manufacturers:

Abbott Furnace Co Mr. Thomas Jesberger 1068 Trout Run Road St. Marys, PA 15857, USA Tel +1 814 781 6355 Fax +1 814 781 7334	**Sarlin Furnaces AB** Mr. Anders Jerregård Bastborregatan 5, SE 72134 Västerås, Sweden Tel +46 21 109800 Fax +46 21 123745	**Seco/Warwick** Mr. Jeff Boswell Mr. Kevin Lipinsky 180 Mercer Street Meadville PA 16335, USA Tel +1 814 724 1400 Fax +1 814 724 1407

6.2.2 Heating Source

It is possible to heat all three types of furnaces with one of the following methods

- Electricity
- Natural gas
- Propane

In many countries, natural gas and propane is a cheaper source of energy than electricity, but requires more maintenance and has a higher initial cost.

Gas burners are known to provide a better temperature uniformity than electrical elements. Gas burners however require a gas tight barrier between the products of combustion and the brazing atmosphere. Such a barrier can be radiant tubes or a muffle.

6.2.3 Nitrogen consumption

For continuos furnaces nitrogen consumption is directly proportional to the opening on either end of the furnace. The formula to calculate nitrogen consumption is as follows:

$$(W_{front} \times H_{front} + W_{rear} \times H_{rear}) \times 100 m^3/h$$

where W = Width and H = Height.

For a batch furnace, the nitrogen consumption is based on the volume of the furnace. Since the door is closed during the cycle, the consumption is less. The nitrogen consumption must be five furnace volume changes per hour. The formula to calculate the nitrogen consumption of a batch furnace is as follows.

$$W_{internal} \times H_{internal} \times L_{internal} \times 5 m^3/h$$

Where L = Length.

Semi-continuos furnaces are a combination of continuos and batch furnaces. Both calculations must be combined. We must determine the time the doors are open and closed over a period of one hour of operation.

6.2.4 Effluent

Effluent is generated when the binder is volatized ☯ 450 °C. This effluent must be dealt with so as not to contaminate the atmosphere in the furnace.

In the furnace, the constant flow of nitrogen will expel the effluent from the brazing atmosphere.

When these fumes exit the furnace the gases must either be burnt or diluted with ambient atmosphere to the local specification. The law changes from country to country and state to state, so one must check with the local authorities before designing a furnace.

7. Post-braze Treatment

7.1. Cleaning after brazing

Normally no cleaning is needed after brazing operation.

7.2. Coatings

The corrosion resistance of a *Cu*proBraze® radiators is better than that of soldered radiators. The nobility of the brazing alloy is of the same level as copper and brass.

*Cu*proBraze® radiators are mechanically strong and facilitate down gauging. High performance coatings further improve corrosion resistance and make down-gauging possible without risks for corrosion problems.

The high performance coating methods are electro-phoretic coating and a special type of multi-nozzle powder coating. The coatings cover the entire external radiator surface – not only about 10% of it like conventional cosmetic spray coating. They clearly prolong the lifetime of copper/brass radiators. The technology for this type of coating is commercially available.

The main process stages in these methods are pre-cleaning, coating and curing. Immediately after *Cu*proBraze® process the radiators are usually so clean that no pre-cleaning before painting is needed.

These coating methods for radiators are able to coat to low thickness levels around 8 micrometers (0.3 mils) which means that the methods do not adversely affect the thermal performance. The methods are also environmentally friendly.

The total cost per radiator is somewhat higher than for spray painting because the entire radiator surface is coated. By accepting the reasonable cost increase, a longer service life, weight savings and environmental and safety benefits will be achieved.

8. Repairing

8.1 Soft soldering

*Cu*proBraze® radiators can be repaired with lead-free soft solders. In *Cu*proBraze® process, copper-tin, copper-phosphorous, and nickel-phosphorous compounds are formed during brazing. Due to decreased wetting of this compounds compared with brass and copper, strong fluxes have to be used. Many of the fluxes used for brazing of stainless steel can satisfactorily be used for repairing. These fluxes give corrosive residues and the careful rinsing of the joints has to be done.

8.2 Re-brazing

Another way of repairing is to apply additional brazing slurry and re-braze. Apply slurry at the failure site and dry. Re-braze the core with the same brazing cycle as usually. During re-brazing the fins will be slightly softer and due to increased alloying of the fins the heat performance may be slightly decreased. Re-braze with the oppcsite side up to keep tube to header joint sealed or to fix tube to header leaks.

How to start

Outokumpu has built a Brazing Center in Västerås Sweden to help customers in building prototypes and evaluating the technology.

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Information updating

BIBLIOTECA CORFO

Websites

www.copper.org	International Copper Association's (ICA) website with general information.
www.outokumpu.com	Outokumpu's website with Brazing Manual and Newsletter articles.

Frequent publications

Executive Report	ICA's paper on CuproBraze
Newsletter	Outokumpu's paper on automotive heat exchangers.

Supplier lists are available at ICA and Outokumpu.

F) Anexos

- Outokumpu, Literatura, Charge Air Cooler y Enfriador de Aceite Desarrollado en Japón.

Cooperation results in shortened lead-time

Strip Products Philosophy

In developing new models of motor vehicles, reductions in lead-time are of great importance. We are convinced that we can contribute to such reductions by collaboration with the automotive industry and in particular, manufacturers of heat exchangers.

Charge Air Coolers and Condensers

New applications of the CuproBraze Process

In developing the CuproBraze Process, interest has been mainly concentrated on its use in fabricating automotive radiators. The radiator is a heat exchanger traditionally manufactured of copper and brass and this is a market which the Copper Industry must defend.

During the work of developing the CuproBraze Process we became aware of significant advantages which make it particularly suitable for use in heat exchangers other than radiators. The process leaves no residues and the strong and solid brazed joints and the high mechanical strength of the material at elevated temperatures are factors which are also of great importance in the manufacture and use of both Charge Air Coolers (CAC's) and condensers.

A CAC is a heat exchanger which cools the air from a turbo-Compressor before it enters the combustion chambers of an engine. The lower temperature and higher density of the air entering the engine makes it possible to burn more fuel at a lower temperature, thereby generating more power with reduced emissions. The CAC must be perfectly clean inside and must withstand stresses at elevated temperatures (up to 280°C). CAC's fabricated using the CuproBraze Process satisfy both these requirements.

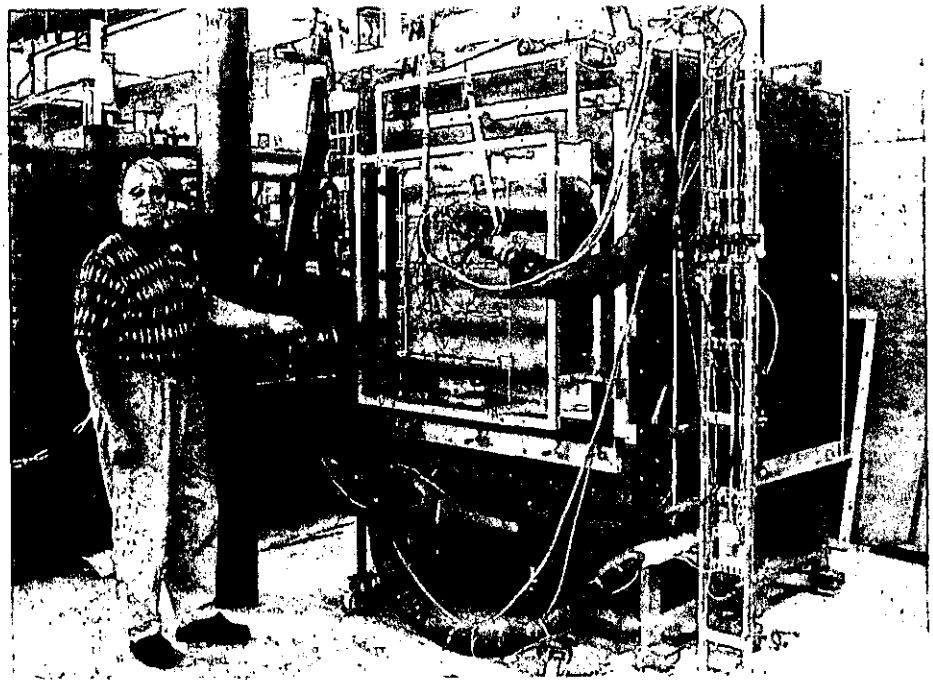
Des Aubry, Technical Manager, Chicago, left, and Bengt Gustafsson, Technical Manager, Västerås study a segment of a CuproBrazed CAC.

As a unit in the refrigerant circuit of the AC system of a vehicle, the condenser must withstand relatively high internal pressure without leakage and its material must not contribute to contamination of the refrigerant. These characteristics are provided by the use of the CuproBraze Process in manufacturing condensers.

When presenting the CuproBraze Process to the automotive industry around the world, we found significant interest in the possible use of the process for both CAC's and AC heat exchangers.

To meet this demand, we now have an extensive development programme under way to adapt the process and to present product concepts in these areas.

Prototype CuproBraze radiators evaluated at Technical Center



Kurt Svanberg, Manager of the Technical Center at Finspång, Sweden, standing by the wind tunnel designed and built by the company.

"The wind tunnel is an important factor in our cooperation with customers. By means of an extremely effective computer program for calculations incorporated in the wind tunnel, we can effectively develop, test and evaluate prototypes for our customers," says Kurt Svanberg, Manager of Outokumpu Copper Strip's Technical Center at Finspång, Sweden.
"Interest is now focussed on CuproBraze and the projects in which we are collaborating with customers."

"Outokumpu Copper Strip is the only manufacturer of strip with its own wind tunnel, and this has been designed, developed and built by the company itself. The development of a prototype for a customer takes between 5 and 7 weeks" continues Kurt Svanberg.
"It can be for example, a prototype with the same performance as the customer's radiator but lighter, being of CuproBraze construction."

Investigation of details

"If the customer has queries and requirements with respect to the prototype, we can study these in detail. All the important elements of a radiator can be adjusted. We can perform calculations to investigate each small part with the help of the calculation program and see the results via the computer."

Tested before delivery

"Each prototype is tested before it is delivered from the Technical Center. The design of each is recorded in a database together with relevant comments."

Outokumpu Copper Strip sponsors The Park World Tour

Outokumpu Copper Strip has decided to become a sponsor of The Park World Tour, the competition for the world's best cross-country runners in the sport of Orienteering.

The Park World Tour started in Vasa, Finland in 1996, initiated by seven orienteering enthusiasts with bases in the Nordic countries. They set a high standard for the different events and placed world-class orienteering in focus. The Park World Tour competitors are the leading 25 men and 25 women cross-country runners and the tour takes these to new countries and new continents where the sport is breaking ground and growing.
The Park World Tour 1998 began in March at Beijing, China. In May, the world's best orienteers competed at Västerås, Sweden and this event was followed by races in Finland, Italy, Austria and the Czech Republic before the final at Gothenburg, Sweden. Interest is increasing strongly and more than 20 countries have applied for entry to the Tour in 1999.
Outokumpu Copper Strip's decision to sponsor the world orienteering championship, together with the Ericsson concern, is based in part on the company's interest in the Chinese market.

continued from page 1

From the President...

tors to the advantage of CuproBraze in these fields.
Outokumpu Copper Strip has an international group of engineers who are at your disposal to provide assistance in projects to develop your products.

Staffan Anger
OUTOKUMPU COPPER STRIP PRODUCTS
Sweden

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NEWS

Outokumpu Copper Strip

November 2000

From the President:

Staffan Anger

World-wide interest in the CuproBraze process

During recent months, several further companies have made the decision to invest in the CuproBraze process. CuproBraze technology is now applied in production facilities in the US in addition to Europe and the Far East. Other companies in different parts of the world are in the final stages of their evaluation of the process which we confidently expect will convince them of the superiority of the CuproBraze process for jointing copper and brass materials in heat transfer products.

Equipment required for the use of the CuproBraze process is now available from different suppliers who offer furnaces of different capacities and the equipment for applying brazing paste to copper-brass radiator tubes and fins.

Why this great interest in CuproBraze technology? Because the market has discovered it to be

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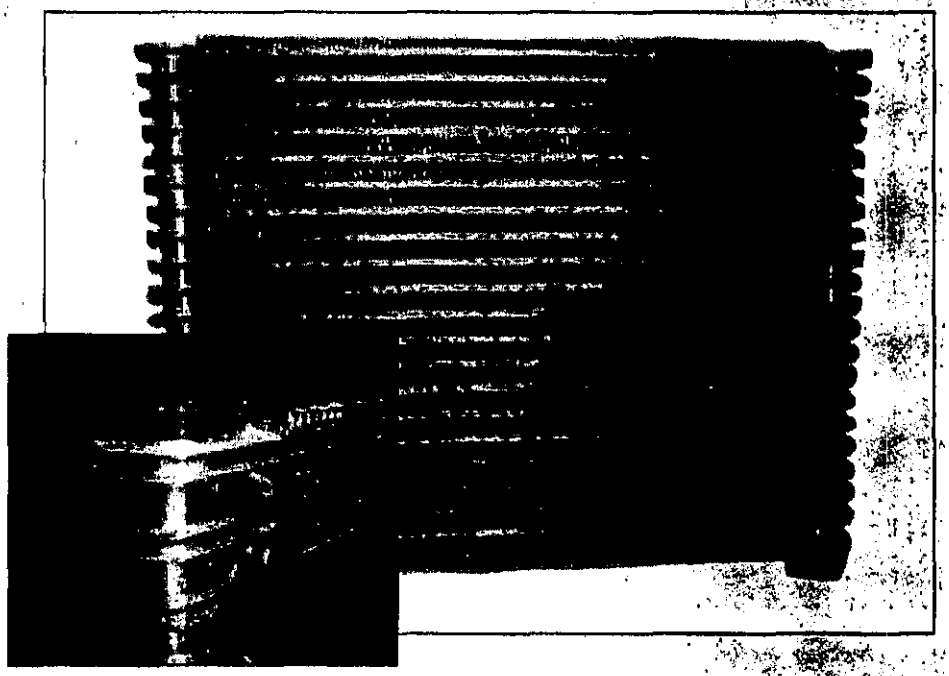
A New Generation of CuproBraze Radiators to be produced in Japan



This photograph shows an oil cooler, fabricated by the Japanese NAJICO company using the CuproBraze process. A closer view of the manifold is given in the insert.

Staffan Anger, President of Outokumpu Copper Strip AB of Sweden has announced that Nakamura Jico Co. Ltd. (NAJICO), a large Japanese manufacturer of industrial heat exchangers has decided to adopt the Outokumpu CuproBraze technology for manufacturing copper/brass heat exchangers and will begin full-scale production of stacked type heat exchangers using the CuproBraze technology during this autumn.

The President of NAJICO, which has its head office at Tsukiji, Chuo-Ku, Tokyo, is **Hiromu Nakamura**. Outokumpu Copper Strip has its Japanese branch office at Nihonbashi, Chuo-ku, Tokyo.

NAJICO will now be the first Asiatic company to adopt the CuproBraze process for use on a commercial basis.

NAJICO was appointed an authorised supplier to the then Japanese Ministry of Railways in 1934 and began supplying parts for buses operated by the Ministry.

The company has since been engaged in the design, manufacture and sale of railway car components and heat exchangers, universal joints for diesel coaches and various industrial machines. It is currently marketing an industrial boiler, a gas turbine type power generator and smoke extraction equipment.

In addition to heat exchangers for railway cars, NAJICO has supplied many heat ex-

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A New Generation...

changers for installation in large power plants. It fabricates heat exchangers for construction machinery, cranes for use on board ships and hydraulic units for incorporation in various industrial machines.

The company has to date used the soldering process in the manufacture of heat exchangers for motors used generally in industrial equipment. It believes that a high degree of efficiency, low production costs, simplified production methods and a reduced impact on the working and general environment will be achieved by making use of the CuproBraze process.

Mr. Hiromu Nakamura, President of NAJICO who made the decision to adopt the CuproBraze technology says "We have studied the performance and durability of heat exchangers and the methods of jointing copper materials for many years. Since 1997, when we first learned of the CuproBraze technology, we have investigated its practicality. It became clear to us that by replacing soldered copper heat exchangers with a stacked type radiator fabricated by means of the CuproBraze process, we would be able to manufacture radiators and oil coolers 20-30% smaller but with the same capacity. Radiator performance would be improved by 30-50% and manufacturing cost reduced by 20-30%. The lead-free process is simpler and is performed in a working environment which is significantly improved.

At present we are studying more effective brazing processes and are in the final stage preparatory to full-scale production beginning this autumn.

Our heat exchangers are used in association with the motors of railway coaches, ships and plant machinery. In such situations, under conditions more severe than those under which motor vehicles normally operate, durability, resistance to pressure, vibration and corrosion are essential requirements. We have been endeavouring for many years to improve copper heat exchangers to ensure these characteristics of strength and durability.

The most critical problems were the elimination of lead-soldering, the development of new brazing paste and the minimising of the thickness of the fin material. We called for technical assistance from Outokumpu and as a result decided to perform practical tests of CuproBraze heat exchangers.

We have now decided to use the CuproBraze technology in manufacturing a variety of heat exchangers and aim at increasing the value of our sales of heat exchangers from a current 1.6 billion to 3 billion yen."

Mr. Gert Lundmark of Outokumpu Copper Strip, in charge of the CuproBraze project in Asia says "We have been engaged in an information campaign with respect to CuproBraze since the spring of this year. We consider that the decision of Nakamura Jico to adopt this technology will demonstrate the strength and durability of heat exchangers on which it is based, its cost-effect superiority and its environmental friendliness. We intend to assemble as much data as possible from this project to encourage wider acceptance of the technology for the manufacture of automobile radiators."

"We very much appreciate the positive attitude of Nakamura Jico in adopting the technology, " he concluded.

Nakamura Jico Co. Ltd.

The Nakamura Jico company was founded in 1929 as a retailer of automobile parts. It was appointed an authorised supplier to the then Japanese Ministry of Railways in 1934.

At present, the company sales department is engaged in marketing railway car components, machinery parts and equipment such as boilers and gas turbines. The manufacturing department designs, fabricates and sells a range of universal joints.

Nakamura has over a 90% share of the market for heat exchangers for diesel coaches built in Japan for domestic railways and for export and has acquired a very high reputation for this product.

The company has its headquarters in Tokyo, a technical laboratory in Takahagi City, Ibaragi Prefecture and manufacturing plants in Tokyo and Gifu City.

Regional sales offices are located in seven cities in Japan. Seven related companies form a group.

The total annual company revenue is approximately 14 billion yen. Of this, 3.8 billion yen is from sales of universal joints and heat exchangers and 8 billion yen from sales of railway car components. The total annual production of heat exchangers is approximately 6000 units of various capacities.

The Nakamura company is extending its business activities internationally through four associate companies overseas.

CuproBraze seminar with focus on production technology

SECO/WARWICK, USA, a world-leading builder of furnaces for the automotive radiator industry recently convened its first CuproBraze seminar. Representatives of companies engaged in all phases of the fabrication process were invited.

"A praise-worthy initiative" summarised Lars Yllner, Manager-Technical Development, Outokumpu Copper Strip, Sweden. "The participants had a unique opportunity to acquire all the CuproBraze information they need and could make important contacts, at one time, at one place."

He attended the seminar together with two other representatives of Outokumpu, John Hipchen and Yoram Shabtay of the Chicago office.

On the first day, John Hipchen presented a

continued on page 3

Fully automatic machines installed at the Brazing Center

Fully automatic machines for the fabrication of CuproBraze radiators are being installed and are undergoing testing at the Brazing Center at Västerås, Sweden.
"We have requests from all over the world for the opportunity to study the automated process," says Kurt Svanberg, newly appointed Manager of both the Västerås Brazing Center and the Technical Center at Finspång.

Kurt Svanberg, at the left, Manager of the Outokumpu Brazing Center at Västerås and Technical Center at Finspång, and Lars Röjeteg study a sample of coated tube produced by the new tube-coating machine in the background at the Brazing Center.

A tube-coating machine and a fin-tip coating machine are now in place and will soon be followed by a header-slurry machine. **Kurt Svanberg** says "The tube-coating machine has been built in collaboration with the German company, Schöler GmbH. It has a high production capacity, is environment-friendly and is the first of its kind for use with CuproBrazing. The header-slurry machine is also a result of cooperation with Schöler GmbH and is unique for this process. The fin-tip coating machine has been designed and built by Outokumpu. Operations previously performed manually are now completely automatic.

The price level we will now be able to hold for the product because of its automation will ensure our competitive position in our market."
As manager of the Technical Center at Finspång, Kurt Svanberg has long and wide experience of development and customer service.
"Development is always difficult but I thrive on challenges. I will have the possibility now of directing the available resources where they are used to the best advantage."

continued from page 2

CuproBraze Seminar ...

paper with the title "Materials and Processes". He was followed by Anil Nadkarni, OMG, who spoke about "Binders, Filler Metal Paste". Jan Schöler of Schöler GmbH chose three different concepts of "Paste Applications Machinery" as his subject and Jeff Boswell, Seminar Director and Kevin Lipinski of SECO/WARWICK concluded the programme of addresses with "CuproBraze Furnace Systems" and "The Titusville Facility" respectively.
The demonstration programme was presented at the SECO/WARWICK Technical Center in Titusville. It consisted of a demonstration of the brazing of copper heat exchangers utilising the CuproBraze process in the new batch furnace which the company has developed. More than 30 visitors from all parts of the world questioned their hosts about the process and the furnace during the demonstration and the panel debate which followed.

The panel at the CuproBraze Seminar at SECO/WARWICK included, from left, Lars Ylliner, Outokumpu Copper Strip, Sweden, Yoram Shabtay, Outokumpu, Chicago, Jan Schöler, Schöler GmbH and Anil Nadkarni, OMG. Seminar Director, Jeff Boswell, absent from the photo, was also a panel member.

"The creation of a comprehensive pi[illegible] of CuproBraze was made possible by inviting experts from the entire manufacturing process. I believe that this was very [illegible] ner," it was an initiative which I hope will be followed-up by other firms engaged in the radiator field."

Copper - the most modern metal

How does the use of copper affect the environment? We will present different aspects of this question in a series of articles in our "Newsletter" written by Mariann Sundberg Lic. Phil. who works with environmental questions within the Scandinavian Copper Development Association. We begin with a brief review of the history of copper in association with the use of the modern CuproBraze technology.

Copper has always been at the forefront of human innovation activities. Both gold and copper occur in solid form in nature and were therefore the earliest discovered metals. The largest known single solid copper find was a huge block weighing 1000 tonnes discovered near Lake Superior in North America. It is believed that copper has been used by man for 10,000 years. The materials used for tools at the time have given their names to different periods in the history of mankind. In addition to the Stone Age and the Bronze Age, archaeologists now speak of an intermediate Copper Age. The remarkable find in 1991, in the European Alps, of the body of a man, now referred to as "Ötzi", preserved for 5300 years in the ice, was made even more interesting by the discovery of a serviceable copper axe as part of his equipment.

This had survived until our time because of the resistance of copper to corrosion.

The most important property of copper today is its excellent conductivity of heat and- in particular- electricity. Silver is the only metal superior to copper in this respect, gold having almost 80% and aluminium 60% of the conductivity of copper. This explains why copper remains at the technical forefront in our electrified world of computers and information transfer technology. Copper remains in great demand for use in cables and computer components but it has many other uses.

Copper is a relatively soft metal and is readily formable. It can be alloyed with other metals without losing its workability. The superior machining properties of certain copper alloys and the ease with which they can be joined give modern users a broad spectrum of design possibilities, in for example, heat transfer equipment such as automotive radiators.

The latest radiator technology is based on the unique heat conduction of copper and the development of the CuproBraze jointing process. In addition to its general technical advantages, the CuproBraze process has a minimum impact on the environment. CuproBraze radiators are fully recoverable for reuse. Because they retain their properties, copper and its alloys are the materials most frequently recycled currently, as they have been for thousands of years in the past. Most copper products on the market today have at least some content of recycled copper.

Perhaps your new CuproBraze radiator contains a tiny proportion of metal from a Copper Age axe!

Activities in Asia

"The entire automotive industry in Asia continues to show great interest in the CuproBraze technology and is acting accordingly," says Gert Lundmark, Marketing Director for Outokumpu Copper Strip in Asia.

"There is an increased interest in Asia in the future possibilities apparent in the new technology and this is reflected in the actions of important actors in this field. Many representatives of the heat exchanger industry were participants at further in-house seminars presented recently in Japan by Outokumpu Copper Strip brazing specialists," continues **Gert Lundmark**. "Seminars have also been held for large audiences from the automotive industry and its suppliers in Malaysia, Indonesia and The Philippines to provide information about our experiences with the new process.

Further seminars are planned

Outokumpu Copper Strip was a prominent exhibitor at the Tokyo Motor Show which even if it focused particularly on the latest in trucks on this occasion, drew large crowds from the general public.

Further seminars and participation in motor exhibitions are planned for the present and next years as parts of our programme to continue our presentation of CuproBraze technology."

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From the President:

more efficient and less expensive and to have a minimum impact on the physical environment. A technology superior to any of its competitors used today by the automotive heat exchanger industry.

Our engineers in Europe, Japan and the US are at your disposal, prepared to set up a demonstration program for your evaluation.

Staffan Anger
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